LOWER DUWAMISH WATERWAY
SLIP 4 EARLY ACTION AREA

integral consulting inc

BIOLOGICAL ASSESSMENT

Submitted to
U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Submitted by
City of Seattle
King County

Prepared by
integral consulting inc.
7900 SE 28th Street, Suite 410
Mercer Island, WA 98040

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ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
ASAOC	Administrative Settlement Agreement and Order on Consent
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
Crowley	Crowley Marine Services, Inc.
CSL	cleanup screening levels
CSO	combined sewer overflow
CWA	Clean Water Act
DAR	design analysis report
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
DPS	distinct population segments
EAA	Early Action Area
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionary significant units
GTSPF	Georgetown Steam Plant outfall
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LTMP	Long-Term Monitoring Plan
LWD	large woody debris
MLLW	mean lower low water
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTCRA	non-time-critical removal action
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	primary constituent element
RAWP	removal action work plan
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation and feasibility study

RM	river mile
SEA	Striplin Environmental Associates
SMS	sediment management standards
SQS	sediment quality standards
TMDL	total maximum daily load
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WQC	water quality criteria

1 INTRODUCTION

The City of Seattle and King County are planning a sediment removal action for early cleanup of contaminated sediments in the Slip 4 Early Action Area (EAA) of the Lower Duwamish Waterway (LDW) Superfund Site in Seattle, Washington (Figure 1-1). The goal of this sediment cleanup is to significantly reduce unacceptable risks to the aquatic environment resulting from potential exposure to contaminants in sediments in the slip. This cleanup will also reduce potential human health risks associated with polychlorinated biphenyls (PCBs) in sediment.

This removal action within the LDW Superfund Site is a federal action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and is therefore required to substantively comply with the Endangered Species Act (ESA). Substantive compliance with ESA means that the U.S Environmental Protection Agency (EPA) will prepare an assessment of effects on listed species for any "major construction activity" within or at the CERCLA action site that is located near listed species or designated critical habitat. This biological assessment is prepared in support of this requirement.

This biological assessment is being submitted concurrently with the design documents for the Slip 4 removal action (Integral 2007) in accordance with the Administrative Settlement Agreement and Order on Consent (ASAOC) for the Removal Action.

1.1 PROJECT BACKGROUND

The LDW was added to EPA's National Priorities List (aka Superfund) in September 2001 because of chemical contamination in sediments. The key parties involved in the LDW site are the Lower Duwamish Waterway Group (LDWG) (comprised of the City of Seattle, King County, the Port of Seattle, and The Boeing Company), EPA, and Washington Department of Ecology (Ecology). EPA is the lead regulatory agency for the sediment investigation and cleanup work under CERCLA; Ecology is the lead regulatory agency for source control work. The LDWG is voluntarily conducting the LDW remedial investigation and feasibility study (RI/FS) under an Administrative Order on Consent. The City of Seattle and King County are conducting the removal action design and construction in Slip 4 under a separate ASAOC for the Removal Action.

Information on the nature and extent of chemical distributions obtained during the LDW Phase 1 Remedial Investigation was used to identify candidate LDW locations for early cleanup action. Slip 4 was identified as a candidate early action area by EPA and Ecology based primarily on elevated concentrations of PCBs, and EPA determined that Slip 4 meets the criteria for initiating a removal action under CERCLA and that the proposed action is non-time-critical. The City of Seattle and King County characterized Slip 4 (SEA

2004; Integral 2004, 2007) and prepared an engineering evaluation/cost analysis (EE/CA) for the removal action (Integral 2006).

The EE/CA includes a streamlined ecological risk assessment that shows that PCBs in surface sediments within the Slip 4 EAA exceed Washington State Sediment Management Standards (SMS) standards (Sediment Quality Standards [SQS] and Cleanup Screening Levels [CSL]) for protection of benthic organisms. The EE/CA also includes a streamlined evaluation of human health risk. The need for a removal action was supported by the qualitative human health risk assessment, which identified three primary routes for human exposure to chemicals in LDW sediments:

- Contact with sediment during commercial netfishing (adults)
- Contact with intertidal sediment during beach play (children)
- Consumption of fish and shellfish (tribal and Asian and Pacific Islander adults and children).

The Slip 4 removal action boundary is based primarily on the areal extent of PCBs because the characterization data showed that PCBs are the contaminant of concern having the largest areal distribution and this distribution includes sediments with elevated concentrations of other chemicals. The removal boundaries were developed with consideration of the SMS criteria corresponding to a low likelihood of adverse effects on biological resources (the SQS for PCBs is 12 mg/kg organic carbon [OC]). Bank soils with elevated PCB concentrations exist along the eastern shoreline of Slip 4. The banks comprise eroding, low-bank bluffs and dilapidated bulkheads and likely include fill material that may be a historic and/or ongoing source to Slip 4 sediments, and are therefore included in the removal boundaries. Areas in the LDW outside of the Slip 4 removal action boundary will continue to be evaluated by the LDWG, EPA, and Ecology under the LDW RI/FS.

The EE/CA presented removal alternatives and recommended a preferred alternative. Following public comment, EPA identified their selected removal alternative in an action memo (USEPA 2006a). EPA has also documented that the selected alternative is in compliance with the requirements of the Clean Water Act Section 404(b)(1)—Dredge and Fill Requirements (USEPA 2006b).

In accordance with the ASAOC, the City of Seattle and King County are submitting the design documents (Integral 2007) for the selected remedy concurrently with this biological assessment. This biological assessment summarizes relevant information from the design documents; however, the design documents present additional detailed information.

1.2 ACTION AREA

The project action area comprises all areas affected by project activities (e.g., in-water remedial actions and offsite disposal). The planned locations and boundaries of specific activities within the action area are described in the Design Analysis Report (Integral 2007). The impact analysis contained in this biological assessment will focus mainly on the immediate project area in and around Slip 4 where potential effects are most likely to occur.

Slip 4 is located on the east bank of the LDW, approximately 2.8 miles from the southern end of Harbor Island. The slip encompasses approximately 6.4 acres and is approximately 1,400 ft long, with an average width of 200 ft (Figure 1-2). Slip 4 is relatively shallow, ranging from +5 ft mean lower low water (MLLW) at the head of the slip to approximately -20 ft MLLW at the mouth. The shallowest depths occur at the head and along the eastern shoreline where the bottom relief gradually slopes to the current and historical dredging boundary located approximately halfway across the slip. The Slip 4 cleanup action area includes approximately 3.83 acres in the northern half, or head, of Slip 4 (Figure 1-3).

1.2.1 Historical Conditions

Dredge and fill operations beginning in 1895 transformed the meandering Duwamish River into the channelized LDW. Most of the intertidal wetlands, shallow subtidal aquatic habitat, and upland habitat along the river were eliminated as a result of the dredging and filling and the urban and industrial development that followed. Less than 3 percent of the historic estuarine habitat remains today (King County 2000a).

Slip 4 was created in the early 1900s and is an arc-shaped remnant of a former Duwamish River meander. Since its creation, aquatic land uses in Slip 4 have included log storage and shipping activity. The earliest land uses in the surrounding upland areas were residences and log storage and other timber-related activities. Industrial land uses began in approximately the 1930s with construction of a saw mill, an equipment manufacturing facility, a lime plant, and an asphalt plant. Airplane manufacturing at the adjacent Boeing property began sometime before 1960.

There have been no previous removal actions or sediment cleanup activities in Slip 4. Known dredging events occurred in 1981 and 1996 when sediments on the west side of the slip were dredged under permit to allow construction of a pier and to improve ship and barge access to the berthing area.

1.2.2 Current Conditions

Currently, most of the Slip 4 EAA[1] consists of sandy mud or muddy shallow subtidal habitat at depths of -4 to -13 ft MLLW (Figure 1-4). Intertidal mudflat habitat exists at the head and on the east side of the slip. Surrounding these aquatic habitats are embankments that transition from about +5 ft MLLW to the uplands at about +18 ft MLLW. Bank soils consist of a surface fill layer (from 4 to 14 ft in depth), underlain by tideflat and river deposits. Nearly all of the Slip 4 shoreline has been highly modified and includes an over-water pier, riprap (some mixed with sand and gravel), wooden bulkheads, and miscellaneous fill. The small areas of unarmored shoreline are generally steep, eroded slopes, vegetated by mixed grasses and shrubs.

Slip 4 is located in a highly developed industrial area, and the shoreline and surrounding areas have been substantially modified and developed. Properties immediately adjacent to Slip 4 are presently owned by Crowley Marine Services Inc. (Crowley), First South Properties, and The Boeing Company (Figure 1-2). Crowley currently owns the majority of the bed of the slip. However, when remedy construction occurs most of the slip bed affected by the removal action will be owned by the City of Seattle. Surrounding upland land uses are industrial or commercial except for a small landscaped park created on Boeing property in the 1990s. Aquatic land uses in Slip 4 included the former Crowley pier and berthing areas. Following acquisition of the Crowley property by the City of Seattle, no shipping or berthing activities will occur within the removal action area (i.e., Crowley's former inner berth area). Crowley activities will continue in their middle and outer berth areas.

Five public storm drain outfalls are located at the head of the slip (Figure 1-2). These storm drains cumulatively drain approximately 830 acres and total flows can exceed 190 cubic feet per second (cfs). Additional private outfalls and storm drains are located along the slip shoreline.

1.3 REPORT ORGANIZATION

This biological assessment is organized into the following sections:

- Section 2 describes the proposed action which includes pier removal, debris removal, bank excavation, dredging, and capping activities.
- Section 3 describes existing environmental conditions in the Slip 4 cleanup action area.
- Section 4 identifies biological resources in Slip 4 cleanup action area.

[1] In this document, the Slip 4 EAA refers to the approximately 3.83-acre portion of the slip and nearby uplands within the defined removal action boundaries.

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- Section 5 identifies state- and federal-listed species in Slip 4, including Puget Sound chinook salmon, Puget Sound steelhead, Coastal/Puget Sound bull trout, and bald eagles.
- Section 6 describes the effects of the planned removal action on environmental conditions and biological habitat.
- Section 7 contains the effects determinations for Puget Sound chinook salmon, Puget Sound steelhead, Coastal/Puget Sound bull trout, and bald eagles.
- Section 8 contains the report reference list.

2 DESCRIPTION OF THE PROPOSED ACTION

The removal action will clean up contaminated sediments within the Slip 4 EAA, which encompasses approximately the northern half, or head, of the slip. Contaminated source material in bank areas adjacent to the removal boundary and in the outfall segment of the Georgetown Steam Plant flume, located at the northern tip of the EAA, will also be addressed during the removal activities. Components of the removal action are described in more detail in the following sections and are illustrated in Figure 2-1. Please refer to the design drawings, specifications, and design analysis report (DAR; Integral 2007) for more detailed descriptions of the removal action components. A summary of the preliminary estimated schedule for the removal action construction is provided in Figure 2-2.

Conservation measures and best management practices (BMPs) will be implemented throughout each phase of this work. The design (Integral 2007) identifies certain specific conservation measures and BMPs, which are also summarized in the following subsections. All in-water work will comply with EPA's Clean Water Act (CWA) 401 Certification, and will be conducted within allowable in-water construction periods identified through the ESA consultation process.

A removal action work plan (RAWP) will be submitted after the contractor has been selected and will identify specific means, methods, equipment, and BMPs that the contractor will use, along with the detailed construction schedule. Refer to the design (Integral 2007) for further discussion of RAWP contents and requirements.

2.1 GEORGETOWN STEAM PLANT OUTFALL

The Georgetown flume conveyance system is located between the Georgetown Steam Plant and Slip 4. It was originally constructed to carry non-contact cooling water from the steam plant to Slip 4, although various drains from other facilities were subsequently connected to the flume.

Significant amounts of accumulated sediment extend from Slip 4 up into the 370-ft outfall segment of the flume, and those accumulations near the outfall (Figure 1-2) are currently being investigated by the City. (Similar accumulations are not present at the other outfalls to Slip 4.) If not removed, the sediments near the Georgetown flume outfall could be transported into Slip 4 following the cleanup. Abandonment, modifications or upgrades to the Georgetown flume outfall structure may also be necessary in coordination with this removal action to ensure proper function of the outfall structure (i.e., free-draining at a low tide), since it is currently at a lower elevation than the sediments immediately adjacent to the outfall.

The City is currently conducting preliminary engineering of alternatives for the Georgetown flume. The following alternatives are being considered:

- Cleaning and re-using the existing corrugated metal pipe outfall
- Abandoning the outfall structure.

A separate design for the entire Georgetown flume conveyance (from the Georgetown Steam Plant to the outfall in Slip 4) is being prepared by the City. It is important that the outfall is functioning properly and the associated source control is in place prior to construction of the cap. Due to sequencing issues, the work on the Georgetown flume conveyance is anticipated to be accomplished under the Slip 4 non-time-critical removal action (NTCRA) authority of EPA, such that permits will not be required. The City is working with EPA to ensure that the design and construction of the flume project meets the substantive requirements of all applicable or relevant and appropriate requirements (ARARs).

The Georgetown flume conveyance design will include measures to remove or otherwise contain any substantial accumulations of sediment from the flume immediately upgradient of the outfall. The design will include removal/disposal of the sediment accumulations, and it is anticipated to include abandoning the existing outfall. The construction of the outfall abandonment or modification will be completed before the construction of the dredging and capping components of this design.

2.2 PIER DEMOLITION

Within the project boundaries, a portion of a concrete pier owned by Crowley extends over the northwest bank of Slip 4. This segment of the pier is no longer used by Crowley and will become City property when the City acquires that part of the Slip 4 aquatic lands that are currently owned by Crowley. Contaminated sediments beneath the pier will be capped as part of this removal action.

Consistent with the Slip 4 Action Memorandum (USEPA 2006a), the City has determined that removal of this portion of the pier prior to remediation is the most appropriate approach to implement the removal action and maintain the sediment cap over the long term, while also improving habitat function.

The segment of pier to be demolished is approximately 450 ft long and 42 ft wide, and extends over intertidal and shallow subtidal habitat. Removal of the pier will eliminate artificial shading over approximately 0.43 acres of aquatic habitat.

The reinforced concrete piling supporting the pier will be cut at the mudline. Treated creosote fender piling at the pier face will be extracted. Portions of the pier demolition that are not considered "in-water work" (e.g., decking and piling cap removal, or removal of piling in the dry) may be conducted outside the established in-water construction window, subject to EPA approval.

2.3 REMOVAL OF TIMBERS, PILING, AND DEBRIS

An estimated 800 tons of timbers, piling, and debris will be removed and disposed of offsite. Piling and other debris encountered during the remediation will be managed in accordance with the substantive provisions of state regulations (WAC 173-304-200), and will be either recycled or sent to a permitted solid waste facility.

Treated timber piling will be extracted by vibratory extraction or dead line pull from a floating derrick. Some pile cutting may be required if a pile breaks above the mudline during pulling. The contractor is required to contain and clean up any sheens or floatable debris from this operation to prevent them from drifting to other areas.

Timbers and piling removed from their current location will be stacked on a barge staging area with filters to limit turbidity of return water. Any sediment brought up onto the barge staging area as part of the piling removal will be contained and disposed of offsite.

2.4 BANK EXCAVATION AND DREDGING

Approximately 6,100 cubic yards (cy) of sediment/soil along 700 ft of shoreline will be excavated to an average depth of 3 ft to prepare a uniform slope for capping no steeper than 2H:1V (Figure 2-1). Approximately 250 ft of this shoreline will be over-excavated to an approximately 3 to 4H:1V slope to expand and enhance intertidal habitat. Also, additional excavation is included above +11 ft MLLW to create two gently sloping backshore areas of about 0.15 acres. Overall, the excavation will create a net 0.08 acres of new aquatic habitat and 0.28 acres of new riparian habitat (from +12 ft MLLW to the top of bank). Refer to Section 6 for a complete discussion of changes in habitat areas associated with the project.

An area from the head of the slip to approximately Station 3+00 will be dredged with mechanical equipment to a minimum of 3 ft, removing approximately 4,100 cy of sediment.

Dredged and excavated materials will be placed on a barge for dewatering on site, with filters to limit turbidity of return water. The dewatered materials will then be transloaded to land, and then transported by truck or rail for upland disposal at a permitted Resource Conservation and Recovery Act (RCRA) landfill that is approved by EPA. The final landfill destination will be identified in the Contractor's RAWP, subject to approval by EPA.

The characteristics of the sediments and bank soils that will be dredged or excavated at the project site are documented in the design (Integral 2007). The materials are contaminated and not suitable for open-water disposal. Disposal of dredged sediments, soils, and debris will be at an established upland solid waste landfill. All offsite treatment, storage, and disposal of CERCLA waste will occur at facilities that are acceptable under EPA's Off Site Rule (40 CFR Part 300.440).

The DAR (Integral 2007) contains a complete description of excavation, dredging, dewatering, transloading, transportation, and disposal techniques. The DAR identifies conservation measures including design criteria, BMPs, operational controls, and engineering controls that will be used to limit environmental impacts from these operations. These are also summarized in Section 2.6, below.

The specifications require the contractor to submit a RAWP that describes the equipment, procedures, materials, methods, disposal location, and personnel to be employed in the work for the dredging, excavation, transloading, and disposal processes. The RAWP will identify additional specific BMPs to be used based on the final equipment and sequencing approaches.

2.5 SEDIMENT CAPPING

Engineered sediment caps will be constructed over 3.68 acres of sediment and embankment areas, and soil covers will be constructed over 0.15 acres of riparian areas. Together, these comprise the entire 3.83 acres of the Slip 4 removal area and over-excavated embankment areas (see Figure 2-1).

Sediment caps will be designed for the following functions:

- Reduce potential chemical flux from contaminated sediments and groundwater, and chemically isolate contaminated sediments from benthic organisms
- Physically isolate contaminated sediments and provide clean habitat for benthic organisms
- Maintain stability under static loads and reliability under design seismic loads
- Resist erosion, suspension and transport of cap materials and underlying contaminated sediments by waves, tidal and wind induced currents, and propeller wash.

Portions of the cap will be thickened and graded to expand and enhance shallow subtidal and intertidal habitat—this will include increasing portions of the cap to thicknesses of up to 5 ft. The engineered caps will be placed over contaminated sediments that are not removed by dredging. The caps will prevent bioturbation of contaminated sediments and provide a clean surface for recolonization by benthic organisms. The estimated total volume of required fill for the capping is 29,000 cy. The final grades in the intertidal area at the head of the slip (Station 0+00 to 2+50) will approximate existing grades. Areas south of Station 2+50 will be 3–5 ft higher than existing grades. Where needed, rock will be used to improve erosion resistance and/or slope stability, and a surface layer of sandy gravel habitat mix will be applied over the rock to improve the ecological function of the surface substrate.

The cap design, including cap thickness and material specifications, is in accordance with the *Guidance for In Situ Subaqueous Capping of Contaminated Sediments* (EPA 905-B96-004). Material specifications are included in the design. Fill materials used for capping after dredging and excavating will be characterized as suitable for in-water placement and will fulfill the physical characteristics necessary to achieve the project purpose at the site.

Specific conservation measures associated with the capping design are as follows:

- Overexcavation of bank areas prior to capping, to increase overall aquatic and riparian habitat
- Design of final cap grades for flatter slopes on embankment areas
- Design of final cap elevations for overall increases in shallow subtidal and intertidal habitat
- Specification of the smallest practicable cap material particles, consistent with achieving the overall cap functions and long-term stability
- Specification of sandy gravel "habitat mix" substrate to be added to areas that require rock armoring and to an existing armored area under the pier (to be demolished).
- Creation of additional riparian/backshore habitat where land ownership permits, as discussed below.

Additional habitat enhancements have been included in the design within RA1 and RA2 where the finished cap surface is above +13 ft MLLW. The goals of the enhancements are to create a stable and more natural riparian/backshore area, to enhance the recruitment and retention of fines, and to provide conditions conducive to establishment of backshore riparian vegetation. The habitat enhancements consist of the following elements, which are shown on the drawings and cover 0.15 acres:

- Overexcavating bank areas on City-owned property to create a gently sloping subgrade at the desired elevations in the habitat areas.
- Placing a soil cover in the habitat areas to contain any remaining contaminants in bank soils. The soil cover includes a base course of waterway cap material to resist erosion during extreme high tides (when waves could move the sand material)

and also to discourage digging. A top course of beach sand will overlie the waterway cap material. The beach sand consists of a well-graded sand with significant fines content and is intended to provide a suitable substrate for vegetative growth.

- Placing anchored large woody debris (LWD) in the habitat areas. Over time, additional LWD may naturally accumulate in these locations. The goal of placing the LWD is to enhance the recruitment and retention of fines and to allow for more rapid establishment and increased survival of vegetation. The LWD is designed to last for several years (potentially decades) and to leave minimal anthropogenic debris when the LWD eventually deteriorates. The LWD consists of partially buried durable native log species (cedar or fir) with rootwads, cabled to buried concrete anchors. The LWD is installed at elevations between +13 ft MLLW and higher, which is the elevation range expected to naturally recruit additional LWD over time. At these relatively high intertidal elevations (above mean higher high water), there is less potential for wave action to dislodge the LWD. When the LWD eventually deteriorates, minimal cleanup (e.g., cutting exposed cable sections) may be desired to remove anthropogenic material.

There is no planned long-term monitoring, maintenance, or adaptive management specific to the LWD or to the potential future natural evolution (or planting) of riparian vegetation. It is anticipated that the areas of habitat enhancement will undergo changes over time due to natural processes.

As noted in the CWA 404(b)(1) analysis (USEPA 2006b), the slip is a depositional environment and is expected to remain depositional. It is expected that in most locations, surface substrates will become finer over time as silts and sands deposit atop the cap.

2.6 CONSTRUCTION BMPs, OPERATIONAL CONTROLS, AND EQUIPMENT OPTIONS

This section presents conservation measures to be employed during construction to limit the short-term effects of the project. A number of BMPs are included as design requirements in the specifications to minimize water quality impacts during all phases of the removal action. These requirements include the following:

- Sequencing dredging and capping activities to reduce the duration that dredged/excavated surfaces remain exposed before capping.
- Specifying stable cut slopes along the prism boundary and between internal dredging units to reduce the potential for sloughing.

- Requiring excavation from the top of the slope down, and capping from the bottom of the slope upward, to reduce the potential for sloughing.
- Requiring bulkhead demolition concurrent with bank excavation to reduce the potential for sloughing.
- Using an environmental dredge bucket to the extent practical, considering debris and other site conditions and with the overall goal of minimizing sediment resuspension during dredging.
- Eliminating multiple bites with the dredge bucket.
- Specifying maximum cut thicknesses to limit any sloughing on the cut face.
- Eliminating sweeping with the bucket or stockpiling of dredged material on the bottom.
- Eliminating the use of grading equipment below the water line.
- Requiring the filtering of return water entering Slip 4 from the materials barge, as material is dewatered on the barge. Material may be mounded on the materials barge to promote drainage.
- Eliminating overfilling of the materials barge.
- Avoiding or minimizing tug activity in Crowley's middle berth during dredging (to be coordinated between the City and Crowley).
- Anticipating relatively low dredge production rates of 400–1,000 cy/day.
- Specifying cap materials with low fines contents to minimize turbidity.
- Controlling liquids and avoiding spillage from transloading activities.

The contractor will submit a RAWP that will identify additional BMPs, operational controls, and equipment options available for minimizing water quality concerns for both day-to-day operations as well as potential contingencies for addressing water quality exceedances. These elements will be implemented, if necessary, to control for turbidity/water quality impacts:

- **Operational Controls** may include the following:
  - Dredging at the head of the slip during lower tidal stages, as practical.
  - Excavating bank areas in the dry, as practical.
  - Decreasing the rate of dredging. This may include decreasing the velocity of the ascending or descending bucket as it moves through the water column; pausing the bucket before digging; or pausing the bucket for longer periods at the water surface to facilitate drainage.

   - Limiting hours of operation to favorable tidal cycles (e.g., avoiding tidal periods that appear to be associated with elevated turbidity conditions).
   - Modifying the positioning of the barge(s).
   - Modifying dredge bucket movement to dislodge adhering material.
   - Decreasing the rate of capping.
   - Releasing cap material from bucket just above the water surface.
   - Adjusting rate of release of cap materials, using smaller bucket or skip box, or increasing swing arc to better pluviate and create thinner lifts.
   - Placing a thinner first lift of capping materials.
   - Stopping work.
- **Equipment Options and Engineering Controls** may include the following:
   - Use of an enclosed or "environmental" bucket. This technology consists of specially constructed dredging buckets designed to reduce turbidity in the water by reducing suspended solids generated during digging and bucket ascent. The presence of extensive debris in Slip 4 limits the ability to use an environmental bucket, and a clamshell bucket will generally be required to successfully remove material containing debris. The specifications call for the use of an environmental bucket to the extent practical, considering debris and other site conditions and the overall goal of minimizing sediment resuspension during dredging.
   - Use of silt curtains/silt screens. The objective when using silt curtains is to create a physical barrier around the dredge equipment to allow the suspended sediments to settle out of the water column in a controlled area. The main advantage of silt curtains is that, if they are deployed correctly, they can reduce surface turbidity. The main disadvantages are that they have little effect on bottom turbidity, and limit navigation in the dredging vicinity. For Slip 4, the contractor will have the option of using silt curtains/silt screens if needed to address water quality exceedances.

The contractor will also be required to control the release of sediment and any associated liquids into the waters around the upland staging area during transloading. BMPs and engineering controls may include the following:

- Constructing and maintaining a containment berm or other confinement method in the rehandling area.
- Using a tight-sealing crane rehandling bucket and monitoring for leakage.
- Minimizing the gap between the haul barge and the dock.
- Using a spill apron between the haul barge and the dock.

- Loading trucks or containers directly from the rehandling bucket.
- Decontaminating and inspecting trucks before they leave the loading area, and requiring immediate cleanup of any material tracked out.
- Collecting liquids from upland containment areas (potentially including any dewatering liquids generated upland, precipitation into "dirty" work areas, and decontamination liquids); filtering, treating, and analyzing the liquids; and disposing of the liquids in the municipal sewer system or into Slip 4. Treated water will be discharged to the municipal sanitary sewer system, under permit from King County, if practicable. If a permit cannot be obtained, discharge into Slip 4 would be in accordance with EPA's CWA 401 Water Quality Certification.

Minimization of potential impacts to adjacent sediments (outside the removal boundary) is also addressed in the design. The specification requirements, BMPs, operational controls, and engineering controls described above will all act in concert to minimize the potential for resuspension of contaminated sediments. Collectively, these elements will greatly reduce any potential for contamination of sediments south of the removal action boundaries. In addition, the design is inherently engineered to reduce impacts to adjacent sediments in the following ways:

- **Separation of dredging activities from project boundaries.** Dredging of the most highly contaminated material at the head of the slip is separated from the removal boundary by approximately 400 ft. Any fugitive residuals from dredging at the head are expected to be minimal and would largely settle out within the area that will subsequently be capped.
- **Avoidance of disturbance to subsurface materials.** No dredging of deeper, buried sediments will occur near the project boundary. The existing clean layers of near-surface sediments will isolate the deeper contaminated material during construction.
- **Cutting of pier piling.** Cutting rather than pulling the concrete pier piling will reduce any disturbance of deeper contaminated sediments.
- **Placement of a boundary berm.** Prior to dredging, a rock berm will be placed at the southern boundary of the removal action. This may reduce any offsite transport of "mud wave" turbidity, although such turbidity is considered unlikely to extend to the project limits. This berm also functions to maintain long-term cap stability at the boundary.

As a contingency, the design includes sampling of adjacent sediments south of the removal boundary both before and after construction of the removal action. If sediment contaminant concentrations are determined to be unacceptably elevated as a result of the removal action construction, the City, King County, and EPA will determine appropriate response actions. This could include placement of a thin layer (6–12 inches) of waterway cap material in the affected area.

2.7 LONG-TERM MONITORING PLAN AND MAINTENANCE

Post-construction documentation will include a long-term monitoring plan (LTMP) in which procedures associated with cap monitoring, repair, and maintenance will be identified.

The design also includes an institutional controls implementation plan that identifies institutional measures to provide additional steps to ensure long-term protection for maintaining the integrity of the cap.

3 BASELINE OR EXISTING ENVIRONMENTAL CONDITIONS

Existing water quality and habitat conditions influence the potential success of the completed sediment remediation action. The baseline environmental conditions of the Slip 4 action area have been characterized in previous reports (e.g., King County 1999; Ruggerone et al. 2006; USACE 2003; Integral 2006). These reports' findings on water quality, physical habitat quality, and biological habitat quality are discussed in more detail in the following sections.

3.1 WATER QUALITY

Ecology is responsible for setting water quality standards based on water use and water quality criteria. The waters of the LDW are designated Class B waters. Pollutants within the LDW are derived primarily from industrial point and non-point sources, stormwater runoff, discharges from vessels, bank erosion, and resuspension of contaminated bottom sediments.

Since the 1960s, enforcement of the Clean Water Act and subsequent state water quality standards and implementation of the National Pollutant Discharge Elimination System (NPDES) have resulted in substantial improvement in water quality conditions in the LDW and estuary. Diversion of wastewater effluent to deepwater outfalls in Puget Sound has significantly reduced the biological oxygen demand in the estuary (USACE 2003). Of the parameters for which historic data are available, all contaminants have been controlled to the point where few exceedances of state chronic water quality criteria, or thresholds for effects on salmonids, have been reported in recent years (USACE 2003). Since the mid-1980s, there have been no reports of direct mortality of salmon or other fish in the estuary; problems previously associated with delayed chinook upstream migrations due to low dissolved oxygen barriers likewise have not been reported since the diversion of the Renton Treatment Plant outfall (USACE 2003). However, the LDW remains on Ecology's 303(d) list of threatened and impaired waters. The potential future development of total maximum daily load (TMDL) limitations for a number of parameters is expected to result in additional improvements in water quality.

Ruggerone et al. (2006) collected water quality data for the Juvenile Chinook Duwamish River Studies in 2005 for the Water Resource Inventory Area 9. The overall goal of the studies was to provide information that would be useful to planners in making decisions on how and where to improve salmon habitat in the lower watershed. Water quality data were collected from February 3 through July 12, 2005, at 12 locations along the Green/Duwamish River corridor. Three stations were located below river mile (RM) 4, including one just upstream and across the river from Slip 4. Water quality parameters included salinity, dissolved oxygen, temperature, and Secchi depth.

3.1.1 Turbidity

Sediment transport within the LDW is influenced by such variables as the movement of the saltwater wedge, sediment loading from upstream sources, channel morphology, and resuspension processes from propeller scour and dredging. Suspended sediment sources and transport pathways in the LDW have been evaluated by King County during two investigations (Harper-Owes 1983; King County 1999). These investigations found that almost all sediment transported into the LDW from upstream sources is deposited in the upper reaches of the LDW near Turning Basin 3. Downstream from the Turning Basin, bulkheads and piers, and heavy armoring along the LDW and adjacent Elliott Bay shorelines, reduce shoreline erosion and generally cause a sediment-starved condition (Harper-Owes 1983; King County 1999). The highest sources of turbidity in the LDW are periodic pulses of sediment moving downstream following seasonal rainfall events. Localized temporary pulses can also result from prop-wash from adjacent marine facilities and barge traffic.

Water quality data from the U.S. Geological Survey sampling gauge at the Foster Golf Links golf course in Tukwila, Washington indicate that the LDW generally reaches its maximum suspended sediment levels between December and March (USACE 2003). Occasional high levels of suspended sediment also occur during the late spring and even into the summer (e.g., 274 mg/L on March 19, 1997, 264 mg/L on August 7, 1997, 101 mg/L on March 22, 1998), which is likely due to intense precipitation from seasonal storm events (USACE 2003).

Secchi depth, which measures water clarity, was monitored in the Green/Duwamish River corridor by Ruggerone et al. (2006) from February to July 2005. Water clarity was greatest in the lower estuary and lower transition zone (RM 1 to RM 5.5) (9.5 ft) compared to the up-river stations (7 ft). Light penetration and its effect on photosynthesis and the production of oxygen play a significant role in the estuarine habitat quality of Slip 4. High concentrations of particulate matter suspended in the water column can smother benthic habitats and reduce visibility for fish seeking prey.

3.1.2 Dissolved Oxygen

The LDW is a saltwater wedge estuary with a lower layer of nearly undiluted seawater moving upstream from Puget Sound and a surface layer of riverine fresh water mixed with saltwater. The saltwater wedge is present in the LDW throughout the year, and, in the vicinity of Slip 4, the waterway generally remains stratified with a distinct freshwater/low salinity surface layer overlying a saltwater bottom layer. This stratification under certain tidal or current conditions can cause stagnation and a decrease in dissolved oxygen (DO). While Slip 4 may not be a persistently stratified area, it is possible that the slip experiences decreased DO with depth and during the summer months.

Ruggerone et al. (2006) measured DO concentrations in the Green/Duwamish River corridor as part of the Juvenile Chinook Duwamish River Studies. Dissolved oxygen at the 2.5-ft depth, as measured from February to July 2005, was found to be adequate for salmon in all areas, but the lower estuary and lower transition zone where Slip 4 is located tended to have lower DO (8.2 to 9.5 mg/L) compared with the up-river sampling stations (10 to 11.5 mg/L).

Salmonids require high levels of DO (8–9 mg/L) to maintain their physiological functions (McCauley 1991). Both migrating adult and juvenile chinook are reported to actively avoid areas with low DO (generally less than 5 mg/L) concentrations (Davis 1975; Whitmore et. al. 1960; Hallock et al. 1970).). However, the Ruggerone et al. (2006) data suggest that DO concentrations that might impact salmonids are not present near Slip 4.

3.1.3 Temperature

In the LDW, the relative temperatures of the freshwater inflow and saltwater intrusion from Elliott Bay primarily influence water temperature (Warner and Fritz 1995). The range of temperatures over depth is influenced by the tidal stage. Ruggerone et al. (2006) measured water temperature collected by thermographs suspended from floats at six locations along the Green/Duwamish River corridor from February through July 2005. Temperatures measured from Kellogg Island (RM 1) to the Turning Basin (RM 5.5) were influenced by both fresh and marine waters. Marine waters were warmer than fresh water in February. Beginning in mid-April, marine waters were cooler than fresh water, and the daily 24-hour range at each location was 7°C. The stable lower range in daily temperature was most likely established by the relatively stable temperature of marine water.

The variation in water temperature with depth provides adult and juvenile salmonids some refuge from higher temperatures throughout most of the year. However, in the late summer and early fall, the general range of temperatures offers no refuge from temperatures considered outside the preferred range for sensitive salmonid species. Lack of large vegetation in the riparian zone has also been cited as a significant cause of elevated temperature in the LDW (USACE 2003). Due to nearshore development and industrialization of the river bank, there is a lack of riparian trees along the shoreline of Slip 4. Thus, the contribution of vegetation as an effective buffer against increasing water temperature from direct sun exposure is probably minimal for the Slip 4 EAA and the LDW on the whole.

3.1.4 Contamination

The State of Washington has established water quality standards for the protection of aquatic life. The LDW is included in Ecology's 2004 303(d) list of impaired water bodies that do not meet state water quality standards. It is currently identified as failing to meet water quality standards for fecal coliform bacteria, DO, temperature, and pH, as well as numerous chemicals in sediments, including PCBs (Ecology 2004). Many of these chemicals are bioaccumulative and have the potential to adversely impact organisms in the aquatic food chain. Total PCBs, PAHs, metals, and other chemicals have been detected in clam tissue samples from Slip 4 at higher concentrations than found at other locations in the Duwamish River (Windward 2005). Total PCBs and total dichlorodiphenyltrichloroethane (DDT) have also been found at higher concentrations in juvenile chinook salmon collected from the mid-portion of the LDW (including Slip 4) (Windward 2004c).

Water quality continues to be degraded by contaminant exposure due to the re-suspension of contaminated bottom sediments and will continue to be degraded until contaminated sediments are removed or isolated from the aquatic environment.

3.2 PHYSICAL HABITAT QUALITY

Two basic aquatic habitat types can be identified in the Slip 4 EAA based on depth, sediment grain size, and general topography. The first is sandy mud or muddy shallow subtidal habitat. This area is within the general footprint of the inner berth at depths of -4 to -13 ft MLLW and is over 60 percent silt and clay. The second general habitat type is intertidal mudflat at the head and on the east side of the slip, composed primarily of 15–60 percent silt and clay, and is found at depths of +4 to -4 ft MLLW (Figure 1-4). Surrounding these aquatic habitats are embankments that transition from about +5 ft MLLW to the uplands at about +18 ft MLLW. Bank soils consist of a surface fill layer (from 4 to 14 ft in depth), underlain by tideflat and river deposits. The fill is generally sand and silty sand with possible layers of silt. Nearly all of the Slip 4 shoreline has been highly modified and includes an over-water pier, riprap (some mixed with sand and gravel), wooden bulkheads, and miscellaneous fill. The small areas of unarmored shoreline are generally steep, eroded slopes, vegetated by mixed grasses and shrubs.

3.2.1 Sediment Contamination

Urban and industrial development in the Green/Duwamish River system has resulted in numerous anthropogenic sources of contamination, including industrial discharges, combined sewer overflows, stormwater runoff, and shipping-related sources (e.g., accidental spills, treated pilings; Tetra Tech 1988). Sediments within Slip 4 contain concentrations of multiple chemicals that exceed the sediment management standards

(Integral 2006). Sediments in the EAA contain PCBs, metals, oil and grease, pesticides, and polycyclic aromatic hydrocarbons (PAHs).

3.2.2 Water Current Patterns

Slip 4 is an off-channel feature that is relatively quiescent which allows for sediments to deposit over time. The western side of the slip has been dredged in certain areas to facilitate navigation, with dredging occurring in 1981 and 1996 (Integral 2006). Circulation in the Duwamish Waterway is controlled by freshwater inflow and tidal action. In general, on a rising tide, water in both the bottom saltwater wedge and surface layer flows upstream. On a falling tide, the flow is downstream. Although water moves upstream and downstream with the tides, circulation in the vicinity of Slip 4 consists of a net downstream flow in the surface layer and a net upstream flow in the salt wedge layer (King County 1999).

3.2.3 Disturbance/Noise

The highly industrialized nature of the LDW subjects it to frequent and intense marine traffic, and the consequent noise and disturbance associated with commercial and industrial facilities along the shoreline. However, marine traffic in Slip 4 is limited to occasional recreational vessels, fishing vessels, tugs, and barges. Existing noise and disturbance levels are typical of highly industrialized areas. Regular heavy tug operations associated with berthing activities will continue in Slip 4 outside the removal action boundaries (i.e., in the middle and outer berths). However, tug activities will no longer be permitted within the City-owned portion that contains the removal action area.

3.3 BIOLOGICAL HABITAT QUALITY

3.3.1 Estuarine Habitat

Slip 4 is part of the LDW estuarine system that also includes East and West waterways and Elliott Bay. The intertidal portion of the action area contains sand, mudflat, and intertidal beaches and the adjacent shorelines are almost entirely armored. Sandy mud or muddy shallow subtidal habitat exists in the inner berth area at depths of -4 to -13 ft MLLW. Prior to channelization of the Duwamish River, Slip 4 was a free-flowing river oxbow that likely lacked the significant intertidal areas currently found near the head of the slip.

3.3.2 Benthic Habitat

Slip 4 is a shallow, quiescent water body with broad intertidal areas near the head of the slip. Sediments are relatively fine-grained, which is indicative of the quiescent nature of the area. Benthic organisms have been observed in the intertidal sediments, although no formal benthic community data have been collected. The total organic carbon content of the sediments is generally less than 3 percent, which is similar to other areas in the LDW.

3.3.3 Forage Fish

Surf smelt and Pacific sand lance spawn on beaches within Puget Sound but likely not in the Slip 4 EAA due to the unsuitability of modified shorelines. Armoring and other shoreline modifications have reduced the amount of available spawning areas.

4 BIOLOGICAL RESOURCES

Slip 4 is located in a highly developed industrial area, and the shoreline and surrounding areas have been substantially modified. Nearly all intertidal wetlands and shallow subtidal aquatic habitats within the Duwamish River corridor have been eliminated as a result of development. Since 1995, 10 small intertidal marsh restoration projects have been constructed downstream from the Turning Basin (Low and Myers 2002), but none are in the immediate vicinity of Slip 4. However, the shoreline and marine areas in Slip 4 retain some of the habitat values of natural estuarine environments. Except for a small park that was constructed in the 1990s, most upland habitat at Slip 4 has been developed.

In this section, the general types of habitat found in the Slip 4 area are described, followed by brief summaries of biological resources that are likely to be present in the area. The shoreline and adjacent uplands at Slip 4 have not been systematically surveyed, but information on general habitat types was available from aerial and site photographs and site visits. Little specific data or information on species in Slip 4 were identified during this review.

4.1 HABITAT TYPES

Most upland areas surrounding Slip 4 are developed, although there is some natural area associated with the public park on the southeast side of the slip (at Boeing Plant 2). The park is partially landscaped with ornamental and native flowers, shrubs, grasses, and trees. Species characteristic of disturbed areas (e.g., blackberries) are present along the shoreline, slope, and paths.

Nearly all of the Slip 4 shoreline has been highly modified and includes berths and wharves, riprap (some mixed with sand and gravel), exposed geotextile material, bulkheads, and miscellaneous fill. The small areas of unarmored shoreline are generally steep, eroded slopes, vegetated by mixed grasses and shrubs. There is little overhanging vegetation.

At Slip 4, two basic aquatic habitat types can be identified based on depth, sediment grain size, and general topography. The first general habitat type is sandy mud or muddy shallow subtidal areas. These areas are found along the center and northwest sides of Slip 4 at depths of -10 to -17 ft MLLW, and are over 60 percent fine-grained material. The second general habitat type is intertidal, at the head and on the southeast side of the slip, and is mudflat, composed primarily of 30–60 percent fine-grained material (Figure 1-4).

There are also hard structures such as a pier, pilings, and riprap. The existing aquatic habitat in Slip 4 supports populations of benthic and epibenthic invertebrates, likely provides habitat for migratory and resident fishes, and may provide feeding and resting areas for shorebirds, waterfowl, and marine birds.

4.2 BENTHIC INVERTEBRATES

Several studies have characterized the benthic community on the mudflats and remaining remnant marshes in the Duwamish River estuary (Low and Myers 2002). These studies have emphasized the importance of the estuarine environment in providing prey organisms for salmonid species. No benthic community data for Slip 4 were found during this review. Benthic invertebrate sampling by the LDWG in 2004 did not include any sampling locations in Slip 4 (Windward 2005). The following descriptions are based on communities in similar habitat types and the limited monitoring results from other locations in the Duwamish. Results of the 2003–2004 LDW clam, crab, and shrimp surveys are described in Section 4.2.2 below.

4.2.1 Benthic Community

Cordell et al. (1994, 1996) sampled benthic invertebrate communities at two intertidal reference sites in the Duwamish: Kellogg Island and the Turning Basin. The grain sizes at these two locations are similar to intertidal areas at Slip 4, containing approximately 35 percent fines. Mean porewater salinities at Kellogg Island and Turning Basin No. 3 (10.8 and 5.3 ppt, respectively) likely bracket those at Slip 4. Intertidal benthic invertebrate assemblages were similar to other locations in the Duwamish River estuary. Although there were differences between sites, the dominant benthic macrofauna included nematodes, oligochaetes, the gammarid amphipod *Corophium* spp., the cumacean *Leucon* sp., the polychaetes *Manayunkia aesturina* and *Hobsonia florida*, and several species in the family Spionidae. The bivalve *Macoma* spp. was present at most stations. The benthic meiofauna (smaller marine organisms) community was dominated by harpacticoid copepods and nematode worms (Cordell et al. 1994, 1996).

There are several outfalls at the head of Slip 4, as well as smaller stormwater discharge pipes that may or may not be active. Discharges can dramatically affect and alter the benthic communities in their immediate vicinity. For example, a benthic community survey conducted off the Duwamish/Diagonal combined sewer overflow (CSO) and storm drain found localized increases in abundance of organic enrichment-tolerant species, such as *Capitella* sp., and an overall reduction in diversity (King County 1999).

It is important to note that the benthic invertebrates in intertidal and subtidal habitats of the lower Duwamish are important as prey organisms for resident and migratory fishes, including outmigrating juvenile salmon (Thom et al. 1989; Simenstad et al. 1991; Cordell et al. 1996) and for resident and migratory shorebirds (Battelle et al. 2001; Cordell et al. 2001). The epibenthic organisms that are important in the diets of salmonids, and some shorebirds, are abundant in areas of sand and silt and among gradually sloping riprap containing sand and gravel. However, areas of steeply sloping riprap under concrete berths or aprons are less productive feeding habitat for juvenile salmonids (Meyer et al. 1981).

4.2.2 Shellfish

Shellfish in the LDW include crab, shrimp, clams, and mussels. Windward (2004b) identified the beach along the east side of Slip 4 as high-quality clam habitat; the area at the head of the slip was categorized as low-quality habitat. Quantitative clam surveys included sampling at the east beach. The July 2003 survey reported two clams (tentatively identified as horse clams [*Tresus capax*]) in Slip 4. In the August 2003 survey, Windward (2003b) reported finding eight clams in Slip 4, including two Baltic tellins (*Macoma balthica*), three bent-nose clams (*Macoma nasuta*) and two sand gapers (*Mya arenaria*). The resulting population estimate was 0.47 clams/ft^2, but there may be considerable uncertainty with this estimate as the distribution was highly variable and patchy.

Windward (2004a) sampled one location along the Slip 4 southeast shoreline as part of a LDW crab and shrimp survey. Samples were collected quarterly. The samples in Slip 4 contained two Dungeness crabs (*Cancer magister*) in the September 2003 survey, zero crabs in the November 2003 survey, and one and five slender crabs (*Cancer gracilis*) in February and May 2004 surveys, respectively. No shrimp were caught in Slip 4. Mussels inhabiting pier pilings are observed in Slip 4.

4.3 SALMONIDS

The Duwamish River provides habitat for young and returning adult salmonids of both native and hatchery stock. General information on these species is summarized below. Salmonid species currently in the Green/Duwamish River system include:

- Chinook salmon (*Oncorhynchus tshawytscha*)
- Coho salmon (*Oncorhynchus kisutch*)
- Chum salmon (*Oncorhynchus keta*)
- Pink salmon (*Oncorhynchus gorbuscha*)
- Steelhead (*Oncorhynchus mykiss*)
- Cutthroat trout (*Oncorhynchus clarki clarki*).

Prior to the mid-1930s, pink salmon also used the Green/Duwamish River; however, these runs were essentially eliminated from the drainage until a few years ago (Williams et al. 1975; WDFW et al. 1993). In 2001, a significant number of pink salmon were observed in the river for the first time in 80 years. The Washington Department of Fish and Wildlife (WDFW) estimated that there were approximately 7,000 salmon, most likely strays from the Snohomish system, which had a huge run that year along with other north Puget Sound rivers (Cropp 2003, pers. comm.). More successful years for pink salmon occurred in the Green/Duwamish River in 2003 and 2005, with conservative estimates in 2005 of 200,000 pink salmon. According to WDFW (Cropp 2006, pers. comm.), odd-year pink salmon have permanently reestablished a viable population in the Green/Duwamish River.

4.3.1 Chinook, Coho, and Chum Salmon

Salmon spawning does not occur in the Duwamish River, but begins in the lower Green River (RM 24) and continues upstream (King County 2000a). Both adults and juveniles are found in the LDW. The majority of salmonids in the LDW during the spring and summer are juveniles (Meyer et al. 1981; Weitkamp 2000; King County 2000a). Ruggerone et al. (2006) found that chum salmon were the most abundant salmonid in the lower Duwamish River captured during their study from February to July 2005. Hatchery chinook were present beginning in late March and peaking from late May to early June (Ruggerone et al. 2006).

Table 4-1 lists the salmonid species, stock origin, status, and spawning season for the Green/Duwamish River. Meador (2003, pers. comm.) confirmed juvenile salmon use in Slip 4, reporting that the catch per unit effort in Slip 4 was about 5 to 10 times higher than that for Kellogg Island on the same day. Windward performed juvenile salmon sampling near Kellogg Island, within Slip 4, and north and south of the mouth of the slip in May and June 2003 (Windward 2004c). Results showed the variability of juvenile salmon use of these areas, with the catch at Kellogg Island 6 times greater than that for Slip 4 on the same day (Florer 2003, pers. comm.).

In general, the greatest juvenile salmonid densities are found over shallow, sloping, relatively soft mud beaches (King County 2000a). Juveniles are most often found in water at least 1 ft deep but rarely deeper than 4 ft below the surface (USACE et al. 1994). Juveniles of the various salmon species in the Duwamish tend to be segregated in time and habitat (Table 4-2). For example, chum salmon juveniles are highly oriented toward shallow nearshore areas but are rarely found in deeper, mid-channel areas (Meyer et al. 1981). Chinook salmon juveniles use nearshore areas, but are also found in deeper water. Temporally, juvenile salmonids are most abundant in the Duwamish between mid-April and mid-June. Peak abundance periods are related to hatchery releases.

Upstream migration of adult salmonids occurs throughout the year but is greatest in late summer and fall. Adults tend to stay in shallow nearshore areas before proceeding upriver (King County 2000a). While many Puget Sound salmonid stocks are declining, the Green/Duwamish River chinook and coho salmon stocks are considered healthy

(Cropp 2003, pers. comm.). There is concern, however, that the wild chinook salmon stock may be overestimated due to contributions from hatchery fish.

Puget Sound chinook salmon were listed as a federally threatened species on March 24, 1999 (64 CFR Part 14308). The Endangered Species Act (ESA) requires the federal government to designate critical habitat for species listed under the ESA. Therefore, on August 12, 2005, the National Marine Fisheries Service (NMFS) issued critical habitat designations for 19 salmon and steelhead species listed as threatened under the ESA (70 CFR Part 52630). These designations include a separate rule for 12 listed species, called evolutionary significant units (ESUs), on the West Coast, including the Puget Sound chinook stock. Designated habitat includes all marine, estuarine, and river reaches accessible to listed chinook salmon in Puget Sound, which includes the Duwamish River and Slip 4 (NOAA 2005). Washington State has listed chinook salmon as a candidate species.

Designated habitats focus on specific habitat features called "primary constituent elements" (PCEs) that are essential to support one or more of the life stages of ESA species. The PCEs essential for the various life stages of chinook salmon found in Slip 4 are discussed further in Section 7.1.2.

NMFS published a proposed Puget Sound Recovery Plan for the Puget Sound ESU of Puget Sound chinook salmon for public comment in the *Federal Register* on December 25, 2005. The plan is a collaborative effort involving local communities, state, tribal, federal, and private conservation entities to provide a roadmap for implementation of recovery actions in the Puget Sound Basin.

The NMFS determined in July 1995 that a listing for coho salmon in Puget Sound was not warranted. However, in 2004 this species was designated a species of concern under the ESA due to concerns over specific risk factors. There are two coho stocks in the Green River that spend time in the Duwamish River as juveniles and returning adults. Both are mixed, composite stocks. The Green River/Soos Creek stock is healthy, but the Newaukum Creek stock is depressed.

4.3.2 Steelhead

Steelhead are anadromous rainbow trout that spend their adult lives in saltwater and migrate to freshwater rivers and lakes to reproduce. Unlike salmon, they can survive spawning and can spawn in multiple years. King County (2000a) reports two Green/Duwamish River winter steelhead stocks: a native wild spawning population and an early release hatchery stock. There is also a summer-run hatchery stock. Like the salmon species above, juvenile steelhead use shallow nearshore areas for feeding, refuge, and physiological transition from fresh to saltwater.

All Green/Duwamish River steelhead stocks were closed to fishing in 2004 because of poor projected returns (i.e., below the escapement goal of 2,000 fish) of hatchery and wild fish. In September 2004, a moratorium was placed on steelhead fishing in 12 rivers, including the Green/Duwamish River, which remains to the date of this writing. In an effort to restore steelhead runs, anglers are allowed to take only one wild steelhead per day during the fishing windows of July 1–31 and October 1–November 30 (http://wdfw.wa.gov/fish/regs/wild_steelhead_moratorium_ces.htm). On March 29, 2006, NMFS proposed to list the Puget Sound steelhead distinct population segment (DPS) as threatened under the ESA (50 CFR Part 223, Vol. 71, No. 60). The DPS includes all naturally spawned winter and summer run steelhead populations in Puget Sound streams and river basins, including the Green/Duwamish River. A final determination may be made within a year.

4.3.3 Coastal Cutthroat

Coastal cutthroat have complex life histories, and there are both resident and anadromous populations. Unlike other anadromous salmonids, cutthroat prefer to remain within a few miles of their natal stream. In rivers with extensive estuary systems, cutthroat move among intertidal and upriver areas or into saltwater, wherever they can find food (Warner and Fritz 1995). WDFW (2000) considers the Green/Duwamish coastal cutthroat stock distinct based the geographic distribution of its spawning grounds, but there are insufficient data to be absolutely certain. Few data are available concerning the abundance of this species in the Green/Duwamish River basin. Eleven cutthroat trout were captured in beach seines from February to June 1994 (Warner and Fritz 1995), but these data are inadequate to address current status.

4.3.4 Bull Trout

Until recently, the bull trout (*Salvelinus confluentus*) was considered an inland form of the Dolly Varden trout, but in 1978 biologists determined that the bull trout was a separate species (USFWS 1998). It is difficult to distinguish the two species on appearance alone. Bull trout are highly mobile and exhibit four different life history forms: adfluvial, fluvial, resident, and anadromous (USFWS 1998). They prefer habitats that include the cold waters (<15°C) found in headwater streams, rivers, and lakes connected to natal streams (USFWS 1998). Bull trout have been little studied in their anadromous form, although they are known to migrate through Puget Sound and are believed to spend most of their time in nearshore environments feeding on forage fishes.

Fluvial, adfluvial, and resident forms of bull trout spend their entire lives in freshwater, with the only anadromous form within the contiguous United States found in the Coastal-Puget Sound region. Most migratory populations have been eliminated from their former ranges. Resident bull trout may exist as isolated remnants in the headwaters of rivers that once supported migratory forms. Without connectivity to migratory populations, these populations have low persistence (Reiman and McIntyre 1993). It is unknown what life history forms exist in the Green/Duwamish River system.

Information and data on bull trout presence, abundance, and distribution in the Green/Duwamish watershed are lacking, and the stock status is unknown (WDFW 1998). Watson and Toth (1994) stated "it is unclear whether the Green River supports a population of bull trout." There is no information on the timing or distribution of bull trout spawning, if any, in the Green River (WDFW 1998).

Isolated observations of adult bull trout have been reported in the LDW, including one adult captured at RM 5 in 1994 and two adult bull trout/Dolly Varden (species unconfirmed) at RM 2.1 and 4.0 in the early 1980s. A single bull trout/Dolly Varden was observed at the mouth of the Duwamish River in the spring of 1994 (King County 2000b). Eight adults were captured near Turning Basin 3 during two sampling events in August and September 2000 (Shannon 2001, pers. comm.), September 2002, and most recently in May 2003 (Taylor Associates 2001; NMFS and USFWS 2004). The origin of these fish is unknown. These observations do not necessarily indicate the presence of a self-sustaining population in the Green/Duwamish River system, but may suggest that fish occasionally migrate into the lower river from the upper river or from Puget Sound (King County 2000b).

In November 1999, the U.S. Fish and Wildlife Service (USFWS) listed five DPSs of bull trout within the U.S. as threatened. One of the five DPSs includes the Coastal-Puget Sound DPS, of which there are 34 subpopulations. The listing identified factors such as dams, forest management, agricultural practices, nonnative species, poaching, overfishing, and residential development as contributing to the decline of bull trout populations (50 CFR 17). The bull trout is listed as a Washington State candidate species.

Complying with a court order, the USFWS designated critical habitat for the bull trout on September 26, 2005 (70 CFR Part 56211). In Washington state, the designation includes 1,519 stream miles (including the Green/Duwamish River), 33,353 acres of lakes or reservoirs, and 985 miles of marine shorelines. PCEs essential to the life stages of bull trout in Slip 4 are detailed in Section 7.3.2.

4.4 FORAGE FISH SPECIES

The shallow nearshore areas in the Duwamish River provide habitat for young and adults of over 40 different fish species (USACE 1983; Matsuda et al. 1968; Weitkamp and Campbell 1980; Meyer et al. 1981). A non-salmonid fish species list for the Green/Duwamish River system was compiled by the U.S. Army Corps of Engineers (USACE 1983) and Windward (2003b), and is provided in Table 4-3.

Primary non-salmonid fish species include English sole, Pacific staghorn sculpin, starry flounder, shiner surfperch, snake prickleback, Pacific herring, surf smelt, and Pacific sand lance (USACE 1983; USACE et al. 1994). USFWS performed fish sampling at both the Turning Basin and the Hamm Creek restoration site in 2001 and captured less than 10 Pacific sandlance (Low and Myers 2002). Other estuarine species found in the Duwamish include rainbow trout, bass, bluegill, suckers, sunfish and dace (USACE et al. 1994). Juveniles of many of these fish species rear throughout the spring and summer on mud/sand intertidal substrates in estuarine areas of Puget Sound.

Two fish species occurring in Elliott Bay and possibly the Green/Duwamish River system are proposed for listing (i.e., candidate species) by Washington State: Pacific cod (*Gadus macrocephalus*), and the river lamprey (*Lampetra ayresi*). The river lamprey is also a federal species of concern.

4.5 MAMMALS

The highly developed land use surrounding Slip 4 makes most of the area unsuitable for many species, but the small park on the southeast side of Slip 4 may provide some habitat for terrestrial wildlife. Various small mammals that inhabit urban habitats could be present, including rabbits, opossums, mice, shrews, moles, bats, squirrels, muskrats, and raccoons. There are river otters in the lower Duwamish at Kellogg Island, but lack of suitable habitat makes it unlikely that this species would be found at Slip 4.

The Duwamish River provides habitat for several species of marine mammals that could enter Slip 4, although this is unlikely. Harbor seals and sea lions have been sighted in the Duwamish River corridor. Harbor seals were observed in the vicinity of Slip 4, in fall 2003 (Cummings 2004, pers. comm.). A survey by WDFW in the LDW and Elliott Bay from December 1998 to June 1999 found seals and sea lions on 17 and 16 occasions, respectively, during a 52-day survey period (WDFW 1999). The nearest haulouts to Slip 4 are located on Harbor Island. Steller sea lions and killer whales have been observed in Elliott Bay, but there is no record of these species entering the Duwamish. Similarly, Dall's porpoises are present in the outer bay south of West Point, and minke and gray whales are occasionally reported in Elliott Bay, but these species are unlikely to enter the Duwamish River.

4.6 BIRDS

Table 4-4 lists species of birds that have been documented in the lower Duwamish River corridor from 2003 to 2006 by the Seattle Audubon Society (Desilvis 2006, pers. comm.). Bird species documented as present at Slip 4 include those adapted to urban environments, such as great blue heron, killdeer, a variety of gull species, swallows, sparrows, finches, rock pigeon, crows, Canada geese, belted kingfishers, spotted sandpipers, and European starlings. Bald eagles, peregrine falcons, and osprey have been observed along the Duwamish. Aquatic species include a variety of ducks, such as mallards, gadwall, scoters, goldeneyes, and scaup. Pigeon guillemots, mergansers, grebes, and cormorants may feed on small fish (Cordell et al. 1996; USACE et al. 1994). It is likely that these species would use Slip 4 primarily for resting and feeding, as nesting habitat and cover are limited. Marbled murrelets have been found in the waters of Elliott Bay, but do not occur in the project area. Designated critical habitat for this species does not include the Duwamish/Green River.

4.6.1 Bald Eagle

Bald eagles (*Haliaeetus leucocephalus*) have made a dramatic recovery in their former ranges since the ban on DDT use after 1972 and increased protection of eagle nesting and roosting habitat. The number of breeding bald eagles and trends in localized counts show that Washington State hosts as many as 4,000 bald eagles each winter, of which 80 percent are migrants primarily from Canadian provinces and Alaska. Most eagles concentrate along rivers where they can forage on spawned salmon, carp, suckers, bullheads, and summer die-offs of perch (Stinson et al. 2001).

Bald eagles have been observed foraging in the general vicinity of Elliott Bay and the Duwamish River. However, no known perches or nest sites for these species have been reported near Slip 4. A bald eagle nest is located at Duwamish Head (identified as nest site #1023 by WDFW), which is near Salty's Restaurant in West Seattle, approximately 5 miles from Slip 4 (Port of Seattle 1997). This nest was occupied and active in 2006. Another nest is located on the western bluff, west of West Marginal Way overlooking Kellogg Island (nest site #1402), approximately 4 miles from the project site. This nest was active as of 2002, but recent nesting status is unknown.

The USFWS released its proposal for delisting the bald eagle in February 2006. After a review of public comments, the actual delisting may take as long as 1 year to complete. Once delisted from the Endangered Species Act, bald eagles will continue to be protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Both acts protect bald eagles by prohibiting killing, selling, or otherwise harming eagles, their nests, or eggs. The delisting is not favored by all, as many scientists believe that eagle populations have not rebounded to satisfactory levels yet and that the delisting is premature.

4.6.2 Peregrine Falcon

Peregrine falcons (*Falco peregrinus*) are a federal species of concern that nest in the greater Seattle area and are seen foraging for starlings, rock doves, and small ducks in the Duwamish corridor. A falcon pair has successfully nested under the West Seattle freeway bridge for several years and produced four young in 2006 (Muller 2006, pers. comm.).

Peregrine falcon breeding success in Washington in recent years resulted in WDFW reclassifying the species from state-threatened to state-sensitive status in April 2002.

4.6.3 Purple Martin

Purple martins (*Progne subis*), the largest members of the swallow family, have been observed foraging in the Slip 4 area. These migratory birds are candidates for listing by Washington State because of a loss of nesting habitat and competition from other cavity-nesting birds. However, the recent introduction of artificial cavities mounted on pilings and similar structures, including several along the lower Duwamish, have boosted the populations of purple martins in Puget Sound. There is an active colony at Jack Block Park (approximately 3 miles north of Slip 4) and smaller colonies at Terminal 105 and Kellogg Island (2.5 and 2 miles away, respectively) (Desilvis 2006, pers. comm.).

5 BIOLOGICAL REQUIREMENTS OF FEDERAL- AND STATE-LISTED SPECIES

The following sections discuss the biological requirements for the two listed salmonid species, the bald eagle, and the steelhead that is proposed for listing. The salmonid species, especially, have complex habitat and life cycle requirements.

5.1 PUGET SOUND CHINOOK SALMON

Habitat requirements for chinook salmon include unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions, and a healthy estuarine environment for growth. The importance of estuaries, and particularly shallow nearshore areas, in the early life history of chinook salmon has been well documented (Meyer et al. 1981). These areas provide food, refuge from predators, and acclimation to saltwater (King County 2000a).

Returning adult summer/fall chinook salmon stock use the nearshore areas of the Green/Duwamish River as staging areas to make the physiological transition from saltwater to freshwater. They require sufficient vegetative cover and instream structures such as root wads for resting and shelter from predators. After acclimating to freshwater, the adults move upriver to their natal streams for spawning from late September through December. They have been recorded spawning in the main stem of the Green River, Big Soos Creek, Newaukum Creek, Burns Creek, Mill Creek, and Springbrook Creek, all of which are located above river mile 24 (King County 2000a).

After the young fry emerge from their gravel nests, they search for suitable rearing habitat within side sloughs and channels, tributaries, seep areas, and other stream margins. Most fry inhabit shallow, side margins and sloughs for as long as 2 months. After sufficient growth, juveniles (parr) move away from quiet, shallow areas to deeper, faster areas of the stream and soon thereafter begin their downstream migration and conversion to smolts as they approach the estuaries. Outmigration to the estuaries occurs over a long time period. Typically, fall chinook stocks outmigrate from January through August, but exact times for this stock are not confirmed. Thorpe (1994) reported that juvenile chinook salmon spend an average of 30 days in the estuary before moving to open water.

Juveniles in shallow nearshore areas generally feed on benthic invertebrates, but other prey items include insects, plankton, and, to a lesser degree, other fish (USACE 1983). Principal prey items vary in importance, depending on size, habitat, and time of year. For example, stomach content analyses indicated that chinook prey on epibenthic invertebrates in shallow habitat when they are small, but as they grow they rely more on planktonic prey (Meyer et al. 1981). Juvenile chinook salmon captured in unarmored nearshore areas in Puget Sound often have a higher proportion of beach and terrestrial insects in their stomachs (Sobocinski et al. 2003). Ruggerone et al. (2006) found that midge adults, pupae, and larvae were the most frequent prey found in both wild and hatchery chinook stock sampled from the Duwamish River.

Most of the LDW has been straightened, steepened, and denuded of riparian vegetation. Warner and Fritz (1995) found the largest abundance of juvenile chinook salmon in the remaining shallow, sloping, soft mud beaches of the LDW compared to areas with sand, gravel, or cobble substrates. Slip 4 contains riprapped upper intertidal areas including berths and wharves, exposed geotextile material, bulkheads, and miscellaneous fill, with little to no overhanging vegetation. Benthic communities have not been sampled in Slip 4, but likely provide prey for juvenile salmon. However, discharge from major outfalls at the head of the slip can dramatically affect and alter the benthic communities in their immediate vicinity. PCBs have been found at elevated concentrations in the surface and subsurface sediment within Slip 4 (see Section 3.2.1). These contaminants could bioaccumulate to levels that may impact the ability of juvenile salmon to grow and mature properly (NOAA 2002). Despite these limiting habitat factors, juvenile chinook salmon have been observed in the nearshore areas of Slip 4 (Meador 2003, pers. comm.; Florer 2003, pers. comm.). In May 2003, Windward (2004c) caught 12 juvenile wild chinook salmon within Slip 4 for whole-body tissue and stomach content analyses.

5.2 PUGET SOUND STEELHEAD

Habitat requirements for Puget Sound steelhead are similar to those described for chinook salmon above. Unlike other salmonids, however, steelhead spend a significant portion of their lives in rivers and streams, making them especially vulnerable to changes in water quality and habitat. Habitat loss and modification are the major factors attributing to the decline of Puget Sound steelhead populations and their proposed addition to the ESA list.

Steelhead are unique among salmonids in that they have the most complex life history of any Pacific salmonid species. In Washington there are two major steelhead runs: wild fish that enter the river during fall, winter, and early spring (winter run), and hatchery fish that enter the river in spring, summer, and early fall (summer run). Green/Duwamish River winter steelhead adults enter the river from November to May and generally spawn within the upper Green River and side tributaries from February through June. The hatchery fish head upriver to spawn from May through October and spawning takes place from February to April (King County 2000a).

Unlike other salmonid species, steelhead do not die after spawning, but return to their natal streams to spawn several times during their lifetime. They lay their eggs in small and medium gravel with sufficient water flows to supply oxygen. Wild juvenile winter steelhead either migrate to sea or remain in freshwater as a resident trout. However, the vast majority of steelhead smolt migrate to saltwater. Within the Green/Duwamish River basin, wild steelhead usually spend approximately 2 years in freshwater before migrating to the ocean (King County 2000a).

While in freshwater and estuarine habitat, steelhead feed on small crustaceans, insects, and small fishes. Juveniles will occupy quiet-water margins and off-channel slough areas where the presence of woody debris and overhead cover assist in their food inputs and protection from predators. As growth continues, juveniles will move from the quiet to the faster areas of the stream, which is often coincident with low summer flows. However, during winter high flows, steelhead salmon will spend time in side channel stream habitat protected by the effects of high flows.

Slip 4 may provide nursery habitat for juvenile steelhead and may be occupied, to some extent, by adult trout during migration. However, the altered state of Slip 4, the armored nature of much of the shoreline, the absence of overhanging vegetation, and the presence of major outfalls likely limits their presence and duration in Slip 4.

5.3 COASTAL/PUGET SOUND BULL TROUT

Habitat requirements for growth, survival, and long-term persistence of bull trout are more specific than for other salmonids. These requirements include the following habitat characteristics: cold water, complex instream habitat, stable substrate with low percentage of fine sediments, high channel stability, and stream/population connectivity. Stream temperature and substrate type are especially important factors for long-term persistence of bull trout (Rieman and McIntyre 1993).

Bull trout are sexually mature between 4 and 9 years of age. Spawning occurs in cold tributary streams from August to November; however, the migratory bull trout may begin spawning migrations as early as April and have been known to migrate upstream over 150 miles to spawning grounds (USFWS 1998). Compared to other salmon and trout, the incubation period for bull trout is long (4 to 5 months). Fry hatch in late winter or early spring and emerge from the gravel substrate after about 3 weeks. Some trout migrate to salt water, while others remain in their natal streams (USFWS 1998). Growth, maturation, and longevity depend on the environment; some individuals have been known to live 10 years or more (Reiman and McIntyre 1993).

Side channels, stream margins, and pools with suitable cover and cold zones are areas where juvenile and adult bull trout are frequently found. Small trout are apex predators and require a large prey base of terrestrial and aquatic insects, macrozooplankton, amphipods, and crayfish. Large trout are primarily piscivorous and feed on smaller fish species such as juvenile salmon, whitefish, yellow perch, and sculpin (USFWS 1998).

For long-term persistence bull trout need cold water temperatures to rear, migrate, and reproduce. In warmer waters they will seek areas offering thermal refuges, such as confluences with cold tributaries, deep pools, areas with cover, or locations with groundwater discharge. Water temperatures above 15°C limit bull trout distribution (Reiman and McIntyre 1993).

Bull trout may occur in the project area; however, there are no records indicating their presence. As a quiescent remnant of a former Duwamish River meander, Slip 4 is relatively shallow with a substrate primarily composed of fine material (i.e., clay and silt). There is little to no overhanging vegetation. Currents within the slip are generally low and variable. Surface water temperatures within the Green/Duwamish River continue to increase 2°C each year as a result of increased urbanization, loss of riparian habitat, and increased runoff from impervious surfaces. Hazardous contaminants in the sediments within Slip 4 degrade the habitat for prey organisms of bull trout. All of these characteristics indicate a lack of suitable habitat in Slip 4 for any portion of the bull trout life cycle.

5.4 BALD EAGLE

Habitat requirements for bald eagles include availability of foraging areas with abundant fish resources and large trees for nesting, perching, and roosting. These trees need to have good visibility and an open structure, and be near to prey. Bald eagles prefer habitats near seacoasts, rivers, large lakes, and other large areas of open water. Preferred areas are generally thought to experience little to no human disturbance.

Bald eagles consume a wide variety of foods in addition to fish, such as birds, carrion, small mammals, mollusks, and crustaceans. Birds that are frequent prey include gulls, waterfowl, coots, seabirds, pigeons, and crows. Bald eagles frequently steal fish from ospreys as well as occasional prey from gulls, loons, mergansers, other raptors, and sea otters (Stalmaster 1987). Watson and Pierce (1998) tallied 380 prey items under 67 nest trees near Puget Sound and in the San Juan Islands, and found that bald eagle prey comprised 67 percent birds, 19 percent fish, 6.8 percent mollusks and crustaceans, and 6 percent mammals.

Bald eagles nest in small patches of residential large trees and second-growth forests. Their nests are often located in the most dominant trees along shorelines, which are diminishing due to residential development. Two-thirds of bald eagle nests in Washington are located on private land, and 99 percent of nests are within 3,000 ft of a water body (Stinson et al. 2001). Nests are often reused in successive years. Female eagles lay approximately two eggs beginning in March with hatching occurring in mid-April or early May. Eaglets fledge in mid-July and remain in the vicinity of the nest tree for approximately 2 months (Watson and Pierce 1998). There are indications that some bald eagles have become fairly tolerant to human disturbance near nest sites.

Bald eagles observed along the lower Duwamish River and around Elliott Bay are year-round residents. Wintering bald eagles do not generally congregate along the LDW as is common along other rivers in the state. There are two documented nest sites within the vicinity of Slip 4: along Duwamish Head (#1023), and west of West Marginal Way on the bluff overlooking Kellogg Island (#1402) (Port of Seattle 1997). Perch trees are found along the Alki shoreline and on the west bluff. Juvenile and adult bald eagles have been observed foraging in the Duwamish River corridor, including Slip 4.

6 EFFECTS OF THE PROPOSED ACTION

The pier and debris removal, dredging, excavation, and capping proposed for the Slip 4 EAA may affect aspects of the area's water quality, physical habitat quality, and biological habitat quality. However, the small size of the project (3.83 acres) and the short duration of the proposed action activities will minimize overall impacts. The proposed action is expected to have only short-term negative effects, if any, and to produce long-term positive effects in the EAA and LDW. The nature and extent of expected impacts as well as proposed methods to minimize negative impacts to these attributes are discussed in the following sections.

6.1 EFFECTS ON WATER QUALITY

Dredging, excavation, and capping operations will result in short-term turbidity plumes and possibly minor reductions in DO concentrations in the nearby area. Toxic organic compounds may become suspended; biological and chemical oxygen demand may increase; and light penetration, photosynthetic oxygen production, and pH may decrease. These perturbations are judged to be temporary and localized, and will be reduced by the BMPs during construction. Short-term and localized decreases in DO or increases in turbidity due to remedial activities may result in short-term avoidance of immediate work areas by salmonids. No long-term effects are anticipated.

Because the primary contaminants of concern are hydrophobic PCBs, dissolved constituents are not considered likely to exceed acute water quality standards for the project, based on experience at other sites in Puget Sound including recent monitoring during the East Waterway Phase II Removal Action on the Duwamish River. Effluent water from the on-barge dewatering process will be filtered to reduce turbidity, and returned to the Slip during the dredging process. This return water is expected to be suitable for returning to the Duwamish River. Special monitoring requirements for chemical constituents will be added to the project water quality certification to confirm this expectation. Additionally, water quality monitoring will include DO and turbidity. EPA's CWA 401 Water Quality Certification will specify water quality monitoring requirements and performance standards for DO, temperature, turbidity, and other parameters as appropriate.

Upland wastewaters will be contained, collected, treated, sampled, and discharged to the municipal sewer system or into Slip 4. Treated water will be discharged to the municipal sanitary sewer system under permit from King County, if practicable. If a permit cannot be obtained, discharge into Slip 4 would be in accordance with EPA's CWA 401 Water Quality Certification.

If water quality parameters exceed established standards during dredging or capping operations, corrective measures will be taken. These corrective measures may include the operational controls, equipment options, and engineering measures discussed in Section 2.6, such as modifying dredging or capping activity or equipment; reducing dredging or capping rate; employing a silt curtain; or stopping work operations. These corrective measures would apply until construction operations demonstrate compliance with water quality standards. Compliance with EPA water quality certification standards is expected to minimize water quality impacts during dredging to levels that will not degrade water quality conditions within the action area.

The design of containment caps will ensure that contaminated sediments will be isolated from water. The site will be carefully monitored in accordance with the requirements of the ASAOC.

In summary, temporary impacts to water quality during construction are expected to be insignificant and discountable and are not expected to significantly degrade the existing water quality condition within the action area or have adverse effects on listed species. Therefore, the effects of dredging, excavation, and capping of contaminated sediments will be to maintain or improve water quality at Slip 4.

6.1.1 Turbidity

Dredging and excavation will result in short-term increases in suspended particulates and turbidity within the removal area and mixing zones. Turbidity will be elevated on a temporary and localized basis by dredging and excavation, but total suspended sediment levels sufficient to cause adverse effects to species of concern will be very limited in extent and duration. Therefore, temporary increases in turbidity during dredging are expected to be insignificant and discountable and are not expected to result in long-term degradation of the existing water quality condition within the Slip 4 EAA or to have adverse effects on listed species.

Capping could also result in short-term increases in suspended particulates and turbidity. Turbidity increases are expected to be small because coarse sediments (sands or larger) will be used for most of the cap construction and because intertidal construction work will be completed in-the-dry as practicable. Locally elevated turbidities generated by the remedial action are not expected to affect adult salmonids directly. EPA's CWA 401 Water Quality Certification will specify mixing zone(s) that would not present a barrier to salmonid migration, and hence adult salmonids may avoid locally elevated turbidities.

Temporary and localized increases in turbidity as a result of remedial action may be detrimental to any present juvenile salmonids. However, because turbidity increases will be temporary and localized, there will be available habitat within the action area that will remain unaffected by sediment plumes, and most in-water construction activities will be avoided , any injuries or deaths of juvenile salmonids from sediment plumes are expected to be minimal and are not expected to result in changes to listed salmonid populations.

Dredging, excavation, and capping operations will be carefully monitored and managed to minimize turbidity effects. EPA's CWA 401 Water Quality Certification will specify water quality monitoring requirements and performance standards for turbidity.

6.1.2 Dissolved Oxygen

Dredging, excavation, and capping operations may result in minor reductions in DO concentrations in the nearby area due the suspension of anoxic sediments. These perturbations will probably be temporary and localized. Short-term and localized decreases in DO may result in short-term avoidance of immediate work areas by salmonids. No long-term effects are expected.

6.1.3 Temperature

Dredging, excavation, and capping are not expected to significantly alter the bottom of, affect currents in, or change flow pathways of the Lower Duwamish River. Additionally, the proposed action will have no effect on the distribution or density of riparian vegetation along the waterway. Pier removal will eliminate some over-water shading, which may have a minor effect on water temperature. However, the proposed action is expected to have no significant effect on water temperature at the Slip 4 EAA.

6.2 EFFECTS ON PHYSICAL HABITAT QUALITY

The proposed action has the potential to affect the physical habitat quality of the EAA through impacts to sediment quality, estuarine and shoreline habitat, and noise and disturbance regimes. The actions are expected to improve sediment quality, estuarine and shoreline habitat, and noise and disturbance regimes. Any negative effects are expected to be temporary and minimal. Impacts to the physical habitat are discussed in more detail in the following sections.

6.2.1 Sediment Quality

The project will improve the characteristics of the existing surface by removing contaminated sediments, debris, and wooden piles and replacing them with clean sand, gravel, and rock fill materials.

Caps will be designed according to site-specific conditions using established EPA and USACE design procedures (USEPA 1998). Armored caps are required where erosive forces (i.e., shear stresses) on cap particles would be sufficient to move typical sand cap particles. Where rock is needed for erosion resistance and/or slope stability, a surface layer of sandy gravel will be applied over the rock to improve the ecological function of the surface substrate. Based on observed historical shoaling rates in Slip 4 and the existing fine-grained substrate, expected ongoing sedimentation in Slip 4 will result in a fine-grained surface substrate depositing over time.

The proposed dredging and excavation will remove the highest concentrations of sediment contamination as well as those that are of most concern for exposure within the Slip 4 EAA. Removal of contaminated sediment will result in cleaner sediment in the intertidal habitat, which will benefit benthic and epibenthic resources and contribute to overall improved water quality and habitat in the LDW. The capping of remaining contaminated sediment will reduce the exposure and uptake of the remaining contaminants. At the completion of the removal action, all surface sediments within the Slip 4 EAA will have contaminant concentrations below the SQS. Overall changes to sediment quality are not expected to have an adverse effect on listed species.

6.2.2 Estuarine Habitat Conditions

Table 6-1 summarizes changes in habitat areas and elevation ranges associated with the cleanup. The project will expand shallow subtidal habitat by approximately 0.29 acres and intertidal habitat by approximately 0.50 acres. This expansion is primarily through conversion of existing sublittoral habitat (deeper than -10 ft MLLW). Approximately 0.08 acres of new aquatic habitat will be created as a result of these actions. The proposed dredging, excavation, and capping are not expected to degrade the character or distribution of existing estuarine habitat or to reduce the ability of listed species to use that habitat, and are in fact expected to increase the amount of and improve the quality of available estuarine habitat overall.

6.2.3 Shoreline Habitat Conditions

Nearly all of the Slip 4 shoreline has been highly modified and includes an over-water pier, riprap (some mixed with sand and gravel), wooden bulkheads, and miscellaneous fill. The small areas of unarmored shoreline are generally steep, eroded slopes, vegetated by mixed grasses and shrubs.

Table 6-1 summarizes changes in habitat areas and elevation ranges associated with the cleanup. The proposed dredging, excavation, and capping are expected to improve the character and distribution of shoreline habitat and improve the ability of listed species to use that habitat. Shoreline slopes will be flatter, bulkheads and debris including treated timber and asphalt will be removed, and the overall distribution of habitat will include more upper intertidal habitat that is connected to shallower habitat by gentle grades. This will improve the overall presence of shallow water areas throughout the tidal cycle. Where rock is needed for erosion resistance and/or slope stability, a surface layer of sandy gravel will be applied over the rock to improve the ecological function of the surface substrate.

As discussed in Section 2.5, additional habitat enhancements have been included in the design within RA1 and RA2 where the finished cap surface is above +13 ft MLLW. The goals of the enhancements are to create a stable and more natural riparian/backshore area, to enhance the recruitment and retention of fines, and to provide conditions conducive to establishment of backshore riparian vegetation. The habitat enhancements will include gentle slopes, a sandy substrate, and anchored LWD, and will cover 0.15 acres.

6.2.4 Disturbance/Noise

The proposed removal, dredging, excavation, and capping will temporarily increase ambient noise levels when equipment is operating. Equipment lights will temporarily increase ambient lighting levels at night in the immediate vicinity of the activities, but are not expected to adversely affect neighboring properties or adjacent habitats due to the short duration of their presence. Noise and activity during remediation operations could temporarily deter some species from the adjacent shoreline areas and from the immediate area of the work. Once the equipment ceases operations, there will be no long-term increases in noise.

Temporary increases in noise and disturbance during construction activities are expected to be insignificant and discountable, and are not expected to significantly degrade existing conditions within the Slip 4 EAA or to have adverse effects on listed species. Furthermore, heavy tug operations will not be permitted in the removal action area following remediation, reducing disturbance and noise from baseline levels.

6.3 EFFECTS ON BIOLOGICAL HABITAT QUALITY

The proposed action also has the potential to affect the biological habitat quality of the EAA through impacts to sediment quality, estuarine and shoreline habitat, and noise and disturbance regimes. However, sediment quality and estuarine and shoreline habitat will be improved over existing conditions. Any negative effects are expected to be temporary and minimal. Impacts to the biological habitat are discussed in more detail in the following sections.

6.3.1 Biological Resources

6.3.1.1 Birds

Resident populations of birds that use the LDW are believed to be acclimated to the levels of human disturbance, noise, and the existing, degraded habitats of the EAA (USACE 2003). Resident individuals wintering along the shore or within nearby restored areas of saltmarsh may temporarily avoid the EAA during proposed activities, but are expected to immediately return to their usual foraging areas and behaviors after activities cease (USACE 2003). Therefore, the proposed action is not likely to reduce the foraging prey base for bald eagles. Seagulls and other aggressive birds such as crows and osprey that regularly use the LDW may be attracted to the EAA by any disoriented fish avoiding the water column surrounding construction activities (USACE 2003).

The proposed activities are thus expected to have insignificant and discountable effects on resident birds in the action area and no adverse effects on listed bird species.

6.3.1.2 Fish

It is possible that the proposed dredging activities could entrain fish (USACE 2003). Typically, however, dredges have been found to entrain few or no salmonids or other mobile fishes (McGraw and Armstrong 1988; Larson and Moehl 1988; Larson and Cassidy 1990; Reine et al. 1998). Based on these studies, the proposed dredging is not likely to entrain a significant amount of juvenile, sub-adult, or adult salmonids. Similarly, capping activities are unlikely to entrap mobile fishes, as these species have the ability to maneuver through the water column.

Temporary increases in noise, turbidity, and water column disturbance during proposed activities are expected to deter adult fish from and potentially adversely affect juvenile fish in the EAA during the proposed activities. Because the proposed activities will be confined to a small portion of the Slip 4 EAA and LDW channel at any one time, adult fish can avoid disturbed portions of the water column. Due to the timing of the proposed activities, few juvenile salmonids are expected to be migrating through the waterway or using the adjacent shoreline habitats. The proposed activities are not likely to adversely affect adult salmonids even if their upstream migration overlaps the construction activity period. If any early migrating salmon are moving through the area during proposed activities, they will likely be able to avoid disturbances by maneuvering within the water column. Some juvenile salmon may be adversely affected by the proposed actions, but no adverse effects are predicted on overall salmon populations. Furthermore, the long-term effects of the proposed actions will be to improve habitat quality for both adult and juvenile fish within the EAA.

Therefore, although there will be temporary increases in noise and disturbance, coupled with temporary decreases in water quality surrounding the proposed activities, these are expected to have insignificant effects on local fish populations in the action area and only short-term effects on listed fish species.

6.3.2 Benthic Prey Availability

Dredging will remove most of the benthic community in the area that will be dredged. Capping will smother and eliminate existing benthic communities. Most benthic organisms are relatively sedentary and are unlikely to be able to burrow through a cap; most are also very small. Capped areas will probably experience reduced diversity and productivity for 2 to 3 years following placement of material as the clean substrate is recolonized by relatively stable benthic communities (USEPA and USACE 2002). Recolonization of the capped surface is expected to be relatively rapid, and the sediment quality will be higher than it is currently.

Although there will be temporary decreases in benthic and epibenthic prey within the dredged area, these decreases are expected to have an insignificant and discountable effect on local fish populations and are not expected to have adverse effects on listed fish species. No long-term loss of biological productivity or prey base for juvenile salmonids or bottom fish is likely, and benthic prey diversity, productivity, and availability should be improved over present conditions in the foreseeable future.

The creation of 0.08 acres of new and cleaner aquatic habitat through dredging, excavation, and capping will likely increase benthic prey production, diversity, and availability in the Slip 4 area in the long term. The proposed remediation actions will temporarily degrade, but in the long-term restore, current estuarine habitat quality function of benthic prey availability in the Slip 4 EAA.

6.3.3 Forage Fish Availability

Dredging may interfere with forage fish as they contact the sediment plume that could result from the dredging operation. This impact will be site-specific and should not have a major or long-term impact on forage fish. During the capping phase, adult and juvenile forage fish will likely avoid the EAA, and some eggs and larvae could be entrapped during capping. There will be no capping in known or potential spawning areas. Capping may create additional potential habitat for forage fish spawning in the long term. Physical parameters of the Slip 4 EAA indicate that it is not likely a current spawning area (USEPA and USACE 2002). Remediation activities in the EAA may create suitable forage fish spawning habitat. While use of this habitat by spawning fish is not guaranteed, construction activities will not degrade the use and functions of existing habitats.

Construction-generated sediments may alter the substrate of adjacent areas of the LDW. Careful control of construction sediments will avoid or minimize any potential impacts to nearby areas. Adult and juvenile forage fish are expected to avoid the EAA during construction, and thus will probably be unavailable as prey resources in the activity area. However, they are expected to return to their usual foraging areas and behaviors immediately after project activities cease.

Although there will be temporary disturbance to forage fish populations, insignificant and discountable effects on local forage fish populations are expected to occur in the EAA. These effects are not expected have adverse effects on listed fish species through food web interactions. No known spawning areas will be affected by any proposed activities. The proposed action may create additional potential spawning habitat for forage fish in the long term. For the above reasons, the proposed project will maintain the current habitat quality function of the forage fish community in the Slip 4 EAA.

6.3.4 Intertidal Vegetation

The proposed dredging and capping will remove, bury, or disturb any present intertidal vegetation within the EAA. No eelgrass is present in Slip 4. The additional cleaner habitat created by the proposed activities, however, is expected to be colonized by comparable intertidal vegetation within the foreseeable future. Overall, the proposed activities are not expected to degrade the character or distribution of intertidal vegetation in the long term, or to negatively affect the ability of listed species to utilize any intertidal vegetation in the vicinity of the EAA.

6.3.5 Riparian Vegetation

Bank excavation activities will disturb riparian vegetation along the Slip 4 EAA, but these effects are expected to be insignificant and discountable due to the heavily industrialized nature of the Slip 4 shoreline.

As a result of the cleanup, the scattered patches of trees and shrubs (primarily invasive) that fringe portions of the EAA will be removed where necessary for the construction. The affected areas may revegetate over time. Overall, the proposed activities are not expected to degrade the character or distribution of riparian vegetation, or to negatively affect the ability of listed species to benefit from the scattered areas of riparian vegetation within the slip.

The additional habitat enhancements within RA1 and RA2 (above +13 ft MLLW) are intended to create a stable and more natural riparian/backshore area, to enhance the recruitment and retention of fines, and to provide conditions conducive to establishment of backshore riparian vegetation.

6.4 INTERRELATED, INTERDEPENDENT, AND CUMULATIVE EFFECTS

Interdependent actions are those which have no independent utility apart from the action being considered. Interrelated actions are activities that are part of the larger action and depend on the larger action for their justification. No interrelated and interdependent effects are associated with this action.

Cumulative effects are defined in 50 CFR Part 402.02 as "those effects of future State or private activities, not involving federal activities that are reasonably certain to occur within the action area of the federal action subject to consultation." The proposed action encompasses a portion of LDW. This area is an ecosystem altered by previous dredging, filling, sewage and industrial discharges, and other anthropogenic activities over the past 100 years. Future federal actions, including additional activities permitted under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act, will be reviewed under separate Section 7 consultation processes and are not considered cumulative effects (USEPA and USACE 2002).

The Slip 4 EAA has degraded baseline conditions such as limited habitat for feeding and refuge and contaminated sediments. Significant beneficial effects are expected as a result of the proposed removal, excavation, dredging, and capping. Specifically, these actions will reduce sediment contamination to levels that are protective of human health and the environment. The proposed action is expected to reduce the exposure of fish and wildlife to hazardous materials, to increase the extent of beneficial habitat, and to increase long-term benthic diversity and productivity by providing cleaner substrates. This action also will assist in the improvement of sediment and water quality throughout the LDW by removing or isolating contaminated materials. In addition, conservation measures implemented within the proposed actions to create intertidal and shallow subtidal habitat will offset any short-term habitat disruption incurred due to project execution.

7 EFFECTS DETERMINATIONS

Dredging, excavation, and capping will result in temporary impacts to 3.36 existing acres of aquatic habitat within Slip 4. The primary aquatic resource support functions of this habitat include feeding, resting, and refugia for migratory salmonids, foraging habitat for migratory and resident birds, and food chain support for other marine fish species and small mammals.

The removal action is not expected to jeopardize the continued existence of ESA threatened and/or endangered species. Potential effects of the proposed action for the three threatened species and one proposed threatened species found in this area are summarized in Table 7-1 and described in more detail in the following sections. Potential effects on designated critical habitat for Puget Sound chinook salmon and Coastal/Puget Sound bull trout are also discussed below.

7.1 PUGET SOUND CHINOOK SALMON

7.1.1 Species Occurrence in Project Area

Both adult and juvenile chinook salmon are found in the project area. The majority of chinook salmon in the LDW and Elliott Bay are ocean-type fish that briefly reside as juveniles in freshwater and migrate to estuarine waters within their first year (Ruggerone et al. 2006). Adults move up the LDW for spawning throughout the year, but their numbers peak in late summer and fall. Juvenile fish leave their natal streams and migrate downstream to estuaries between early March and mid- to late summer. Peak abundance periods are related to hatchery releases. Ruggerone et al. (2006) determined that hatchery chinook were present beginning in late March and peaking from late May to early June. Windward (2004c) was most successful capturing juvenile chinook salmon in Slip 4 during the month of May, and most of these fish were wild stock.

7.1.2 Analysis of Effects

7.1.2.1 Species

Contaminated sediments within Slip 4 will be removed by dredging, which will be limited in scope to minimize impacts to adjacent structures and outfalls and avoid conversion of intertidal habitat to subtidal habitat. Approximately 4,100 cy of contaminated sediments containing PCBs and other chemicals will be removed from approximately 0.7 acres of lower intertidal habitat. Approximately 6,100 cy of PCB-contaminated sediments and soils along 700 linear ft of intertidal embankments and within the Georgetown Flume outfall pipe will also be removed. The removal of the contaminated sediments will be beneficial to threatened Puget Sound chinook by greatly reducing their potential exposure to PCBs.

The dredging will be designed to accommodate a sediment cap that covers approximately 3.44 acres of intertidal and subtidal habitat, and approximately 0.39 acres of riparian habitat. The dredging, excavation, and capping will result in some conversions between elevation ranges, including sublittoral, shallow subtidal, lower intertidal, and upper intertidal. This action will cause a net shallowing of Slip 4 and will substantially expand both intertidal habitat areas and shallow subtidal habitat areas compared to existing conditions. The dredging is scheduled to occur between October and February to coincide with the period when juvenile salmon are no longer present in large numbers in the LDW. This timing will also avoid noise impacts to any remaining salmon.

Dredging and placement of clean sediment and removal of pilings will result in a loss of benthic and epibenthic resources, which are major prey items for adult and juvenile chinook salmon. However, these impacts will be temporary. The proposed project will create 0.08 acres of new aquatic habitat at the head of the slip that will be rapidly recolonized by prey assemblages. In addition, shallow subtidal habitat will be increased by 0.29 acres and intertidal habitat by approximately 0.50 acres. Because juvenile salmon migrate and feed along shallow intertidal areas, the increased intertidal habitat will greatly benefit chinook salmon over the long run.

The cap material will consist of clean sand or coarser material that provides suitable substrate for supporting the benthic communities that are prey for chinook salmon. The resulting cap surface is expected to rapidly recolonize with benthic organisms that will provide the same or better prey for chinook salmon as before. In addition, Slip 4 is a net depositional environment and it is expected that fine-grained sediments will accumulate over the cap surface over time. Ultimately, this fine-grained substrate may support a more diverse benthic and epibenthic community and improve prey availability for adult and juvenile chinook salmon.

The dredging and capping will create turbidity in the immediate area as sediments disperse through the water column. However, the coarse materials (sands or larger) used for capping, implementation of BMPs during dredging and construction, and the in-the-dry timing of intertidal construction work is expected to result in only small increases in turbidity. Decreases in DO may also occur. All salmonids require high levels of DO (8–9 mg/L) to maintain their physiological functions (McCauley 1991). Both migrating adult and juvenile chinook are reported to actively avoid areas with low dissolved oxygen (generally less than 5 mg/L) concentrations (Davis 1975; Whitmore et. al. 1960; Hallock et al. 1970). Increased turbidity and decreases in DO will be temporary and localized, and are not expected to affect juvenile or adult salmonids that may be present in the vicinity.

The LDW is included in Ecology's 2004 303(d) list of impaired water bodies that do not meet state water quality standards. It is currently identified as failing to meet water quality standards for fecal coliform bacteria, DO, temperature, and pH, as well as numerous chemicals in sediments, including PCBs (Ecology 2004). Many of these chemicals are bioaccumulative and have the potential to adversely impact organisms in the aquatic food chain. Total PCBs, PAHs, metals, and other chemicals have been detected in clam tissue samples from Slip 4 at higher concentrations than found at other locations in the Duwamish River (Windward 2005). Total PCBs and total DDT have also been found at higher concentrations in juvenile chinook salmon collected from the mid-portion of the LDW (including Slip 4) (Windward 2004c). Juvenile chinook salmon are important prey organisms for bull trout and other fish species. Clams benefit diving ducks, which are a prey base for threatened bald eagles. Removal of PCB-contaminated sediment will result in cleaner sediment in the intertidal habitat, which will benefit these benthic and epibenthic resources and contribute to overall improved water quality in the LDW.

7.1.2.2 Critical Habitat

NMFS designated critical habitat for 19 ESUs of salmon and steelhead, including Puget Sound chinook salmon, in September 2005 (70 CFR Part 52630). As part of the ESU for Puget Sound chinook salmon, the Duwamish Waterway is included in the critical habitat designation, and Slip 4 is considered nearshore marine area critical habitat. For species listed under the ESA, NMFS considers certain biological and physical features called primary constituent elements (PCEs) that are essential to recover the species. Examples include space for growth, food, water, air, light, minerals, protected habitats, and cover sites for breeding, reproduction, and rearing.

There are six PCEs deemed critical for chinook salmon habitat. Of these six PCEs, only PCE #5—nearshore marine areas—applies to Slip 4. These areas need to be free of obstruction and excessive predation with:

(i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

(ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.

The five other PCEs are not relevant to the life cycle or habitat requirements of chinook salmon in Slip 4.

Shoreline habitat within Slip 4 will be greatly improved by the proposed action. Although there will be short-term impacts from the dredging and capping activities, the prey base will improve after removal of the contaminated sediments, intertidal habitat will increase, and natural cover will be provided. Short-term impacts may include resuspension of contaminated sediments, increases in turbidity, and decreases in DO. Water temperatures will not be affected.

7.1.3 Take Analysis

Implementation of the conservation measures, particularly timing construction to avoid salmon migration periods, reduces the potential for incidental "take" of chinook salmon either by harm or harassment. Few, if any, juvenile or adult chinook salmon are expected in the project area during construction activities. The short-term impacts of construction activity are not expected to significantly disrupt chinook salmon to the extent that it would cause injury or "take" of any chinook salmon.

7.1.4 Conservation Measures

To reduce resuspension and mobilization of contaminated sediments during construction, all in-water work will be conducted using BMPs identified in the design specifications and in the RAWP. In addition, all in-water work will be conducted and monitored in accordance with EPA's CWA Section 401 Water Quality Certification, which will specify allowable in-water work periods, water quality monitoring requirements and compliance criteria, and operational responses to any water quality exceedances. The contractor will be required to modify operations or employ other engineering measures (e.g., use different equipment, slow production rate, etc.) as needed to remain in compliance with water quality criteria. All in-water work will also occur during fish window periods determined in consultation with National Oceanic and Atmospheric Administration (NOAA) Fisheries and USFWS (Integral 2007). Dredging will be performed using a clamshell dredge (either a digging or an enclosed bucket), which is the optimum technology for handling debris, minimizing the spillage of materials and avoiding incidental entrainment of juvenile salmonids. A portion of the bank excavation work will be completed when the tides are out and the sediment is exposed, further limiting releases to the water column.

The cap materials will generally consist of sandy gravels, although larger rock armor is required in bank areas, near outfalls, and at the southern boundary of the cap area. To improve substrate quality, habitat mix will be applied to all armored cap areas. As a further conservation measure, habitat mix will also be applied to existing riprap beneath the extant pier in the project area. Portions of the cap will be thickened and graded to expand and enhance shallow subtidal and intertidal habitat—this will include increasing portions of the cap to thicknesses of up to 5 ft. The engineered caps will contain the remaining contaminated sediments, prevent bioturbation of contaminated sediments, and provide a clean surface for recolonization by benthic organisms.

There are currently no eelgrass beds or upper intertidal marsh areas within Slip 4. Expansion and enhancement of the shallow subtidal habitat is a habitat conservation strategy for the Duwamish estuary (King County 2005). The proposed action significantly increases the areas of shallow subtidal and intertidal habitat. Over time, the shallow habitat may become suitable for colonization by vegetation. Some of the highest juvenile salmonid densities are found over shallow, relatively soft mud beaches and eelgrass meadows (King County 2000a); therefore, the proposed action will benefit salmonid and forage fish habitat.

Sections 2.5 and 2.6 identify additional conservation measures that are incorporated into the design and BMPs to be used during construction.

7.1.5 Effect Determination

7.1.5.1 Species

The proposed action may affect but is not likely to adversely affect endangered Puget Sound chinook salmon. Adult chinook salmon would not be present in Slip 4 during the removal action; some juvenile salmon may be migrating through the area. Although there will be some short-term impacts from the dredging and capping, such as temporary degradation of water quality and loss of benthic and epibenthic habitat, these impacts will be limited to the immediate construction area. Because the proposed action has the potential to affect only a small portion of the run, the conservation measures discussed above will minimize these temporary impacts. The proposed action will improve and restore habitat for chinook salmon over the long term. .

7.1.5.2 Critical Habitat

The proposed action in Slip 4 may affect but is not likely to adversely affect designated critical habitat for Puget Sound chinook salmon. The proposed action does not affect all six PCEs that are critical to the recovery of chinook salmon. Only PCE 5 (nearshore marine areas) applies to Slip 4, and effects from the proposed action on this PCE are considered insignificant.

7.2 PUGET SOUND STEELHEAD

The Puget Sound DPS of steelhead was recently proposed for ESA listing (50 CFR Part 223, Vol. 71, No. 60). Effects determinations were included for steelhead in case the proposed listing is finalized prior to completion of the proposed action.

7.2.1 Species Occurrence in Project Area

Steelhead are most likely occur in the project area only briefly during up- and downstream migration and possibly as juveniles. Ruggerone et al. (2006) captured wild juvenile trout (older than 1 year) in small numbers from mid-February to mid-May in the lower Duwamish River (this study did not specifically include the Slip 4 area). Results of the Ruggerone et al. (2006) study suggest that steelhead rapidly migrated through the lower river and estuary to saltwater.

The altered habitat, armored shoreline, lack of riparian vegetation, and major outfalls in Slip 4 likely contribute to the limited presence of steelhead in the slip.

7.2.2 Analysis of Effects

7.2.2.1 Species

The analysis of effects discussed above for chinook salmon also applies to Puget Sound steelhead. The removal action is expected to be beneficial to steelhead by greatly reducing their potential exposure to PCBs and by increasing their available habitat for feeding, resting, and refuge. There will be a temporary loss of benthic food sources through dredging, excavating, filling, and pile removal. However, the resulting clean surface will be rapidly recolonized with benthic communities. Following construction the accumulations of fine-grained sediments that will deposit on top of the cap surface will improve habitat quality over time.

7.2.2.2 Critical Habitat

No critical habitat has been designated for steelhead.

7.2.3 Take Analysis

Implementation of the conservation measures, particularly timing the construction to avoid peak juvenile steelhead migration periods, reduces the potential for incidental take of steelhead either by harm or harassment or impacts to their habitat. Some adult winter-run steelhead may be present in the project area during construction; however, according to the results of the Ruggerone et al. (2006) study, adult steelhead migrate rapidly through the LDW.

7.2.4 Conservation Measures

The conservation measures discussed above for chinook salmon would also minimize any negative short-term impacts to steelhead. After consultation with NOAA Fisheries and the USFWS, in-water construction windows will be designated to ensure that impacts to migratory fish will be avoided or minimized.

7.2.5 Effect Determination

7.2.5.1 Species

The proposed action in Slip 4 may affect but is not likely to adversely affect Puget Sound steelhead or their habitat. Steelhead have been documented in the LDW, but not specifically in Slip 4. Any adult steelhead that are present during dredging activities would readily avoid the project area. The timing of construction will avoid juvenile steelhead migration periods. Overall, the impacts of the proposed action on Puget Sound steelhead are considered negligible.

7.2.5.2 Critical Habitat

No critical habitat has been designated for steelhead.

7.3 COASTAL/PUGET SOUND BULL TROUT

7.3.1 Species Occurrence in Project Area

Bull trout may occur in the project area; however, there are no records indicating their presence. Bull trout have, however, been documented in the LDW. An adult trout was captured at river mile 2.1 in the 1980s, which is just downstream from Slip 4. Eight adults were captured near Turning Basin 3 (river mile 5.1) during two sampling events in August and September 2000 (Shannon 2001, pers. comm.), September 2002, and most recently in May 2003 (Taylor Associates 2001; NMFS and USFWS 2004). The origin of these fish is unknown.

Bull trout are apex feeders that prey on juvenile salmonids, so they are likely found in similar habitats. However, the shallow substrate, warmer temperatures, and lack of currents limit their potential presence within Slip 4, especially during the summer months.

7.3.2 Analysis of Effects

7.3.2.1 Species

The analysis of effects discussed above for chinook salmon applies to the Coastal/Puget Sound bull trout as well. The removal action is expected to be beneficial to threatened bull trout by greatly reducing their potential exposure to PCBs and by increasing their available habitat for feeding, resting, and refugia. There will be a temporary loss of benthic food sources through dredging, excavating, filling, and pile removal. However, the resulting clean surface will be rapidly recolonized with benthic communities. Following construction the accumulations of fine-grained sediments that will deposit on top of the cap surface will improve habitat quality over time.

During dredging and removal activities, DO is expected to decrease over the short term. Bull trout require near saturation level conditions because they are very active fish. They will move away from areas where DO is below 8 mg/L and will not stay in low DO environments (McCauley 1991). Therefore, bull trout will most likely avoid the project area during construction activities.

7.3.2.2 Critical Habitat

The USFWS designated critical habitat for the Coastal/Puget Sound bull trout in September 2005 (70 CFR Part 56211). Unlike the salmonids, bull trout have specific habitat requirements that restrict their spawning and rearing to high quality habitats. They require cold water in areas with abundant cover for successful reproduction. Although bull trout were historically found in the Green/Duwamish River, no spawning population exists today. The designation of critical habitat for bull trout will assist in the conservation and recovery of this species.

Like chinook salmon above, the Duwamish Waterway is included in the critical habitat designation, and Slip 4 is considered nearshore marine area critical habitat for bull trout. There are six PCEs deemed essential to the recovery of bull trout that apply to Slip 4 and include the following:

1. Water temperatures ranging from 36 to 59°F (2 to 15°C), with adequate thermal refugia available for temperatures at the upper end of this range.

   The Slip 4 proposed action will not affect water temperatures. Pier removal will eliminate some over-water shading, which may have a minor effect on water temperature, but the increased shading provided by new riparian habitat over the long term will offset these short-term impacts on water temperatures.

2. Complex stream channels with woody debris, side channels, pools and undercut banks.

   This is not a relevant PCE for Coastal/Puget Sound bull trout because Slip 4 is not a stream channel.

3. Substrates of sufficient amount, size, and composition to ensure egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival.

   This is not a relevant PCE because bull trout do not spawn in Slip 4.

4. A natural hydrograph, including peak, high, low, and base flows within historical ranges, or if regulated, a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily or day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation.

   The Slip 4 proposed action will not affect the Green/Duwamish River hydrograph.

5. Springs, seeps, groundwater sources, and subsurface water connectivity to contribute to water quality and quantity.

   Dredging and capping actions in Slip 4 will not affect any springs, seeps, or groundwater sources that contribute water quality and quantity.

6. Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.

   Although adult bull trout have been observed sporadically in the Green/Duwamish River, the river does not function as a migratory corridor for bull trout. Bull trout have not been observed in Slip 4.

7. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

   The short-term loss of benthic invertebrates during dredging and capping activities would be offset by the increases in benthic habitat and resulting food web expansion after the proposed action. Riparian habitat in Slip 4 is currently marginal, but would be significantly increased as new riparian habitat is created near the head of the slip. Forage fish and juvenile salmonids that are prey species for bull trout may be temporarily impacted by the proposed action. However, the prey base for adult and juvenile bull trout will be improved over the long term by eliminating the potential for prey bioaccumulation of toxic contaminants from the sediments and transfer of these contaminants through the food chain.

8. Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

   Dredging and capping activities in Slip 4 would not affect the quantity of water available for bull trout.

7.3.3 Take Analysis

Bull trout have not been observed in Slip 4. However, if these fish were present during the dredging and capping activities, implementation of the conservation measures described above for chinook salmon would reduce the potential for incidental take of bull trout either by harm or harassment or impacts to their designated critical habitat.

7.3.4 Conservation Measures

The conservation measures discussed above for chinook salmon would also minimize any negative short-term impacts to bull trout. After consultation with NOAA Fisheries and the USFWS, in-water construction windows will be designated to ensure that impacts to migratory fish will be avoided or minimized.

7.3.5 Effect Determination

7.3.5.1 Species

The proposed action in Slip 4 may affect but is not likely to adversely affect endangered Coastal/Puget Sound bull trout. Bull trout have been documented in the LDW, but not within Slip 4. Nevertheless, the work window has been designed to coincide with periods when bull trout and prey species of bull trout are not likely to be present. Any adult bull trout that are present during dredging activities would readily avoid the project area.

7.3.5.2 Critical Habitat

The proposed action in Slip 4 may affect but is not likely to adversely affect designated critical habitat for Coastal/Puget Sound bull trout. Of the eight PCEs essential to the recovery of bull trout, six are applicable to Slip 4. Potential effects of the proposed action on these six PCEs are considered negligible.

7.4 BALD EAGLE

7.4.1 Species Occurrence in Project Area

Bald eagles are year-round residents of the LDW and Elliott Bay, and juveniles and adults have been observed foraging in the project area. Primary habitat for bald eagles includes areas with suitable forest structure (i.e., perching and nesting trees), accessible prey, and low human disturbance. The nearest nests are located at Duwamish Head (5 miles away) and on the bluff overlooking Kellogg Island (approximately 4 miles away). Perch trees are located along the same bluff and at other locations along the LDW corridor.

7.4.2 Analysis of Effects

7.4.2.1 Species

Potential effects of the proposed action on bald eagles include short-term disturbance from construction activities, such as increased noise and water turbidity. The proposed action represents a minimal portion of the available foraging habitat for bald eagles, so no significant effects to prey availability are anticipated. Few adult chinook salmon, steelhead, or bull trout are expected in the project area during the construction activities, so the most likely prey for bald eagles will be waterfowl, which will avoid the construction activity and noise. Bald eagles, in turn, will also temporarily avoid the project area and find prey elsewhere. The closest bald eagle nest is approximately 4 miles away from the project site. Bald eagles in the Puget Sound region begin nesting in late February, which will be after the proposed project work will be completed.

7.4.2.2 Critical Habitat

No critical habitat has been designated for the bald eagle.

7.4.3 Take Analysis

The short-term impacts of construction activity are not expected to significantly disrupt eagle behavior or foraging activities to the extent that it would cause injury or "take" of any bald eagles. The potential for any incidental take of bald eagles is considered negligible.

7.4.4 Conservation Measures

The potential for long-term adverse impacts on bald eagles is negligible; therefore, no specific conservations measures are warranted. Bald eagles will benefit from the conservation measures for chinook salmon described in Section 7.1.4.

7.4.5 Effect Determination

7.4.5.1 Species

There will be no long-term significant adverse impact on bald eagles. The proposed action may result in short-term noise disturbance and reduced prey availability for bald eagles; however, the activity is in an industrial corridor with similar noise effects prevalent. No bald eagle nest sites are located within 0.5 mile of the project area, which is the minimum distance required by USFWS (1999) to avoid disturbance to nesting eagles. Furthermore, the nesting period for bald eagles in Puget Sound commences after the proposed action will be completed. Survival and long-term reproductive success will not be affected. In summary, no effects are expected for bald eagles.

7.4.5.2 Critical Habitat

No critical habitat has been designated for the bald eagle.

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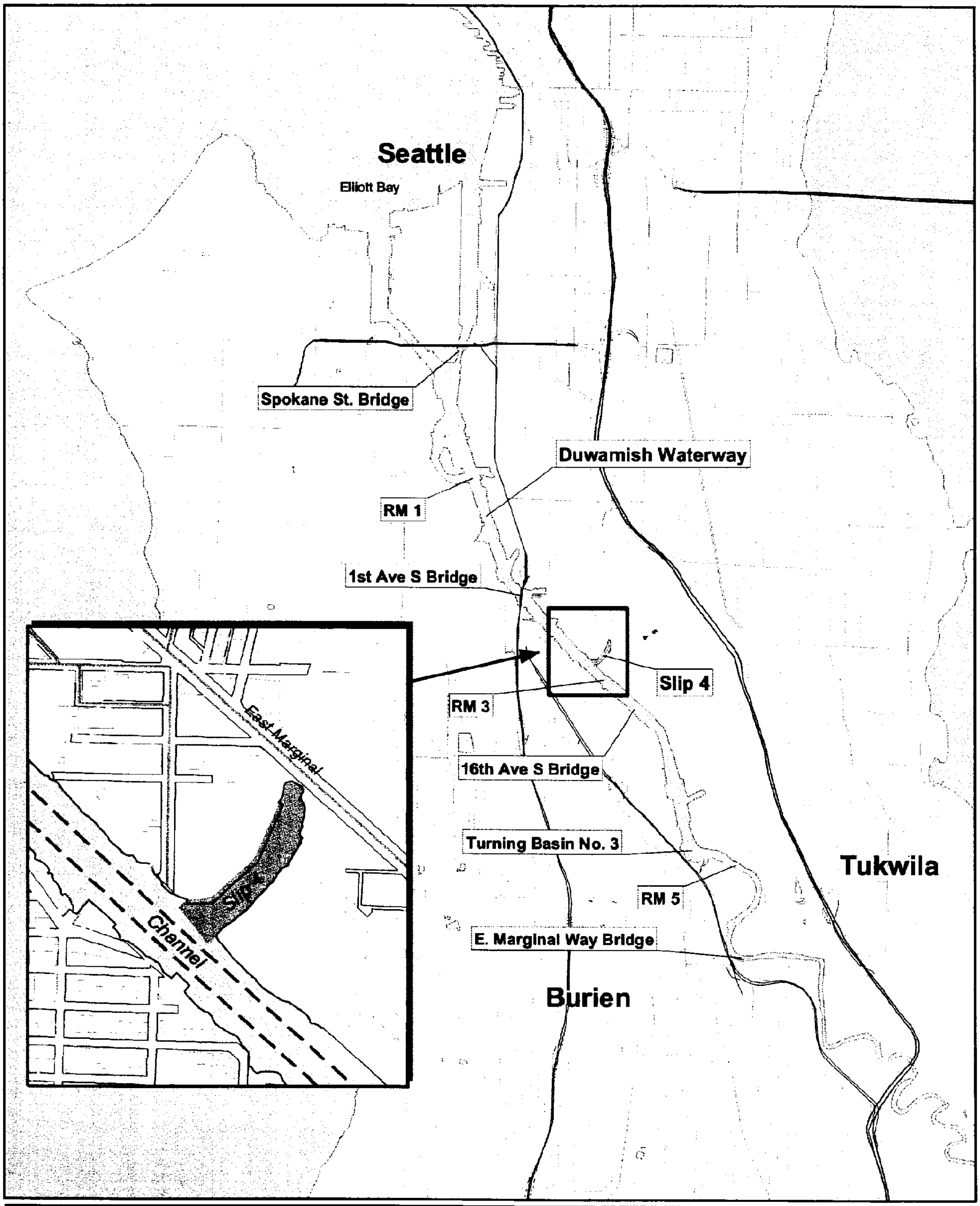
FIGURES



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Map Feature Sources: King County GIS, Seattle Public Utilities, USACE, Ecology, and others

Figure 1-1
Vicinity Map
Slip 4 Biological Assessment

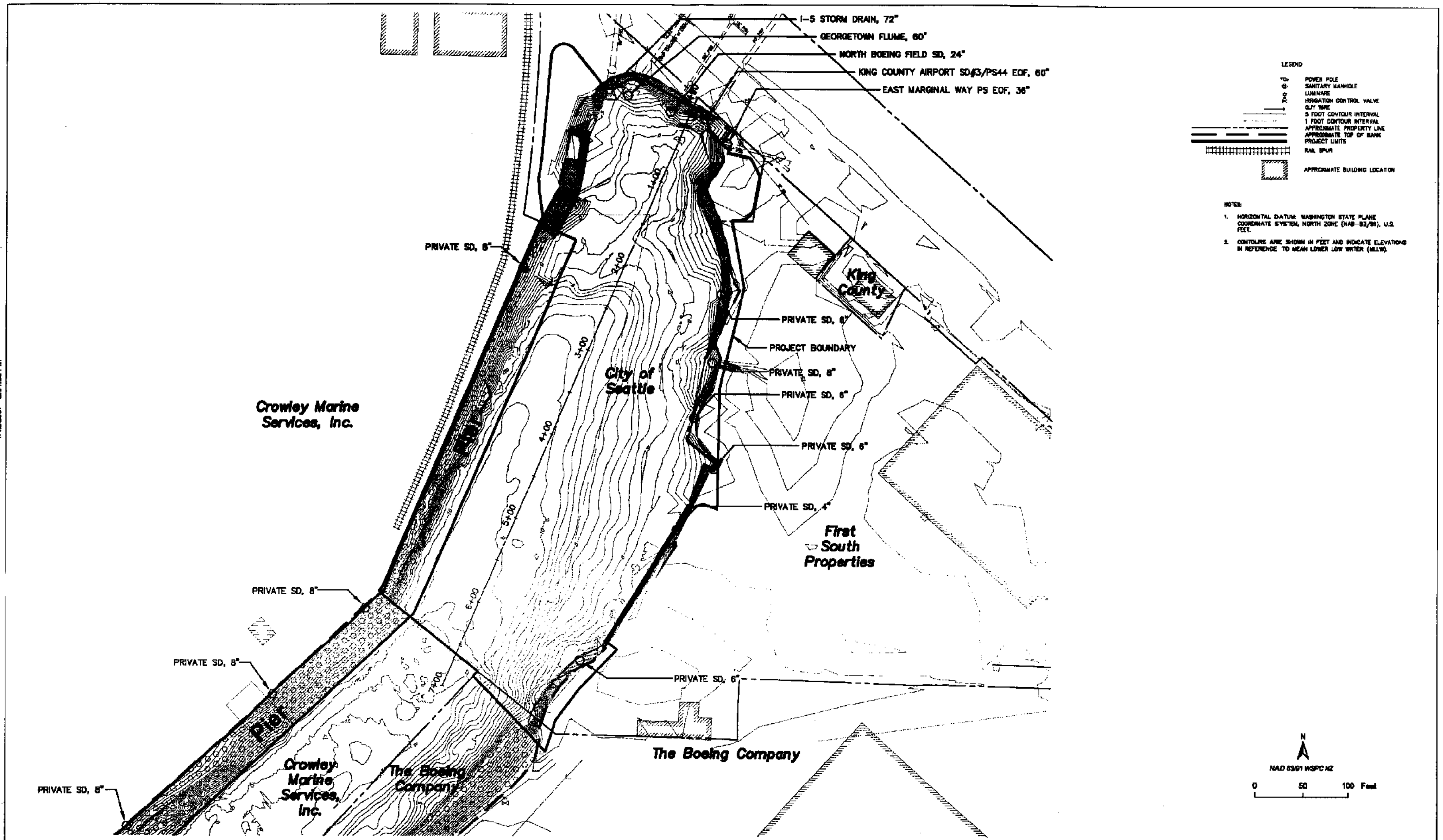

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Figure 1-2
Property Boundaries and Ownership
Slip 4 Biological Assessment

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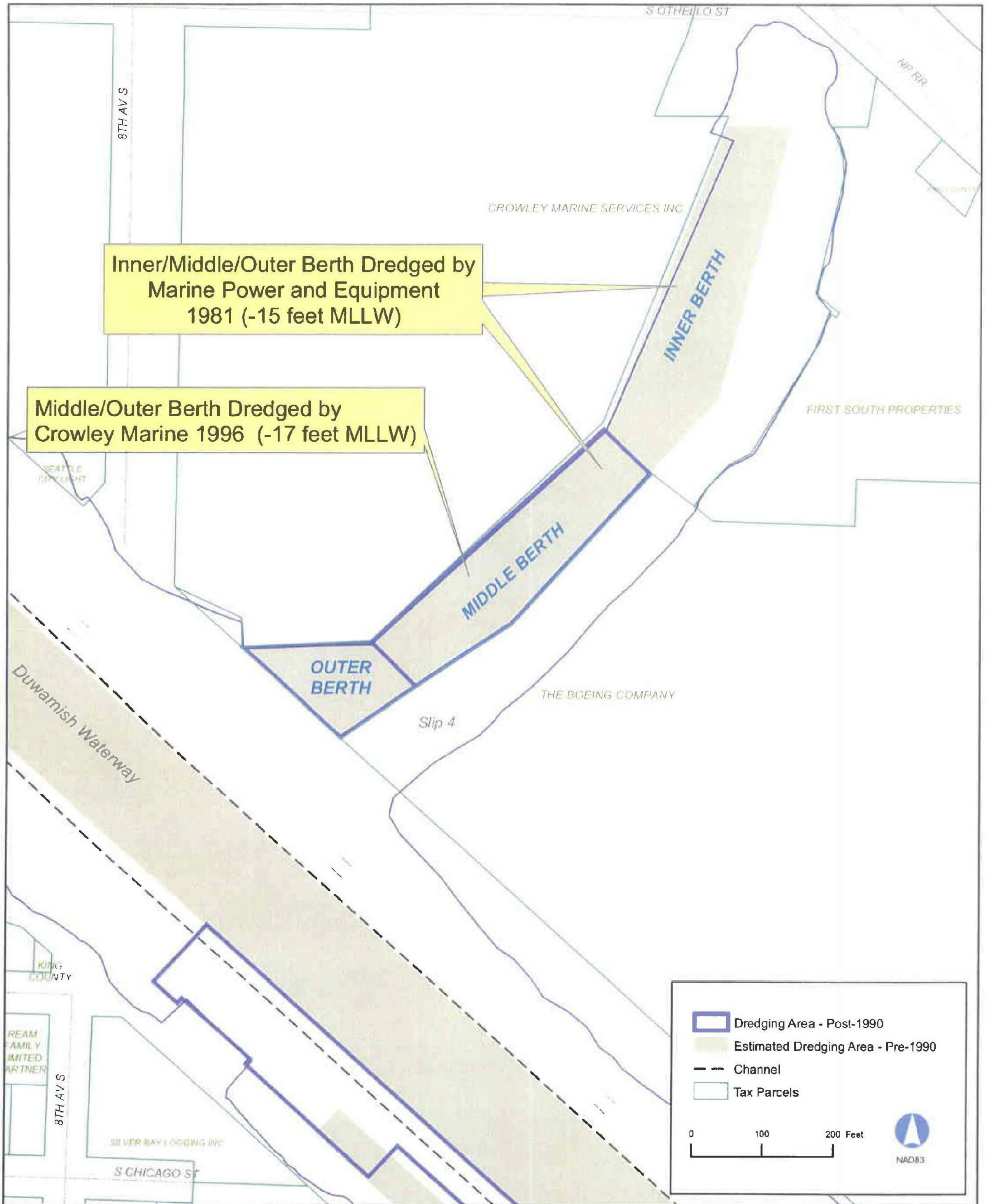

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Figure 1-3
Slip 4 - Biological Assessment
Summary of Historical Dredging

Map Feature Sources: King County GIS, Seattle Public Utilities, USACE, Ecology, and others

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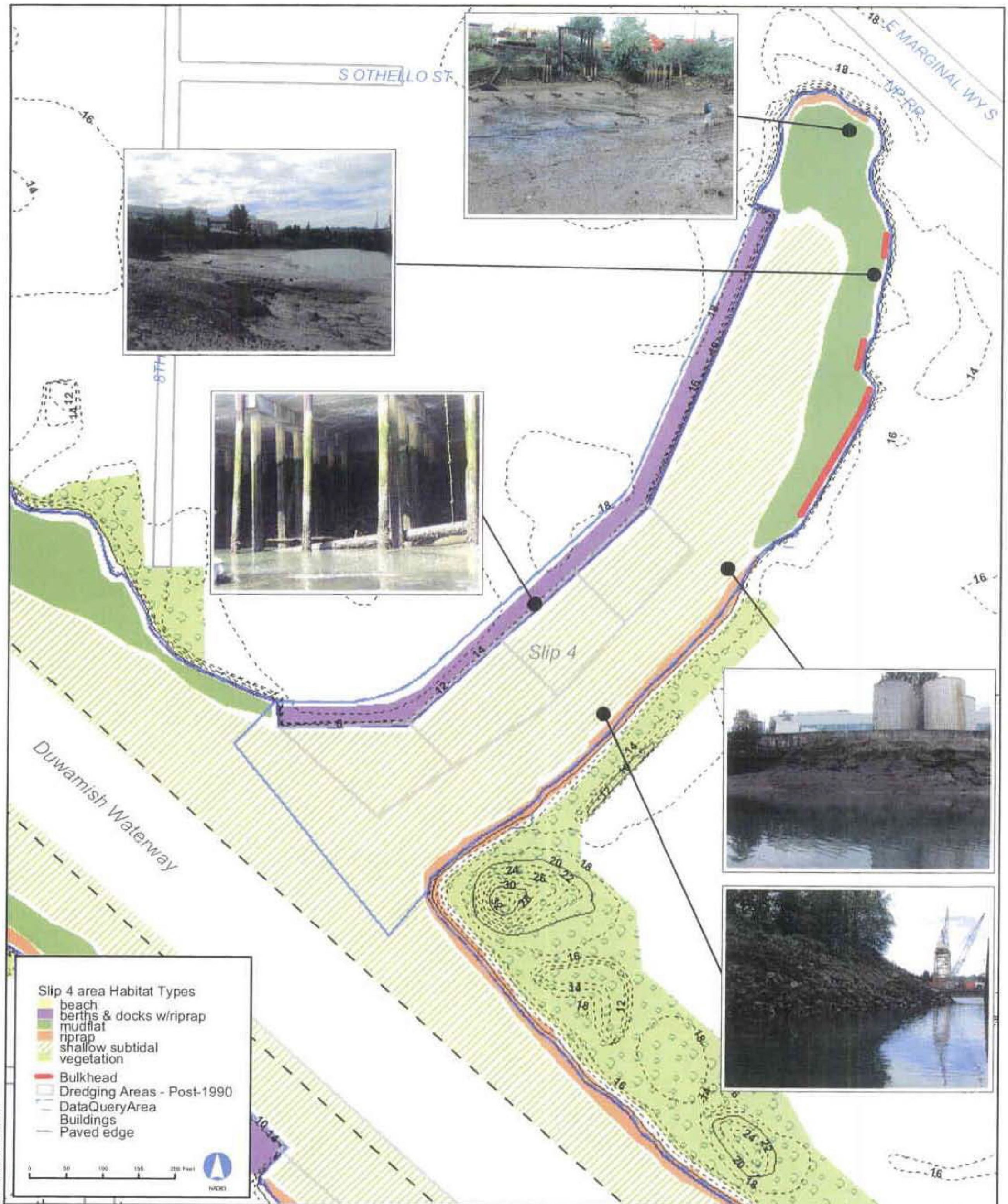

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Figure 1-4
Slip 4 - Biological Assessment
Habitat Types

Map Feature Sources: King County GIS, Seattle Public Utilities, USACE, Ecology, and others

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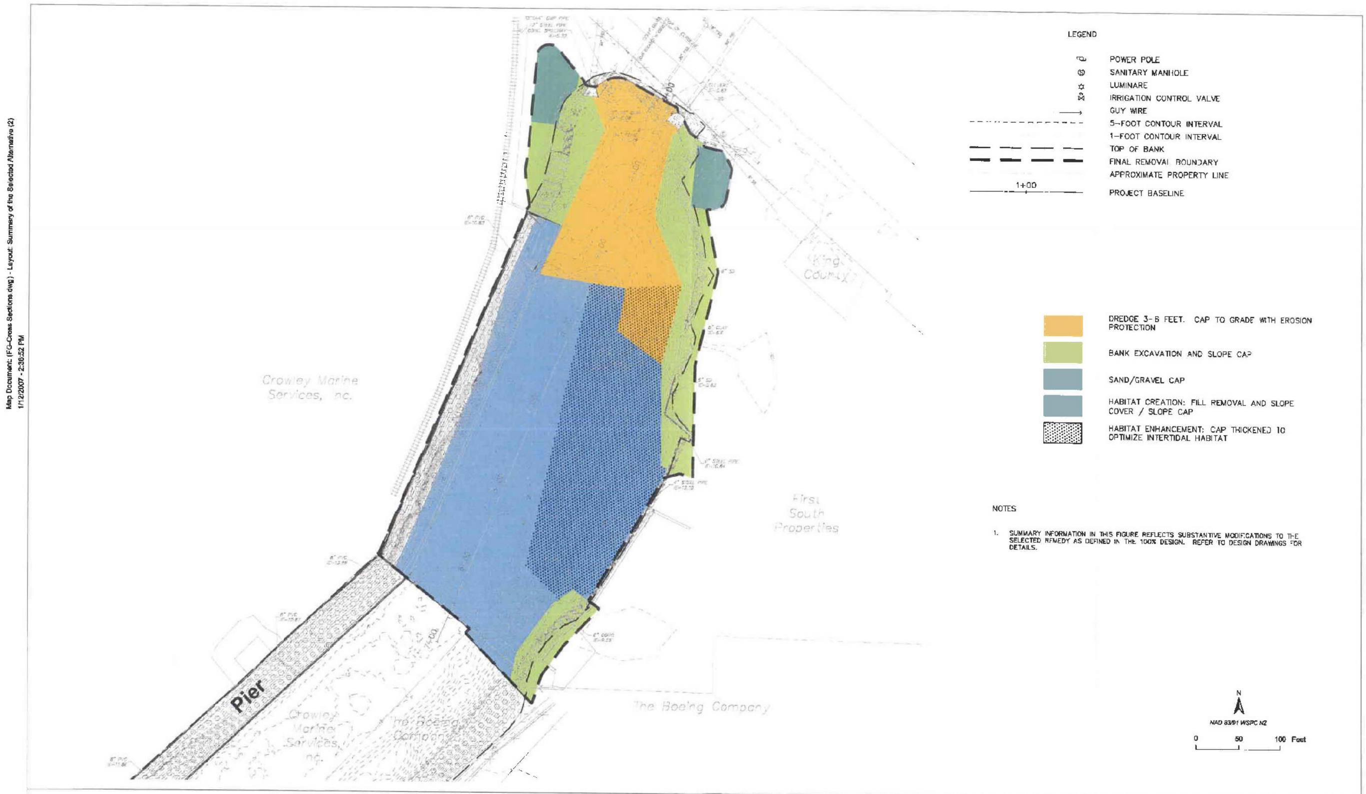

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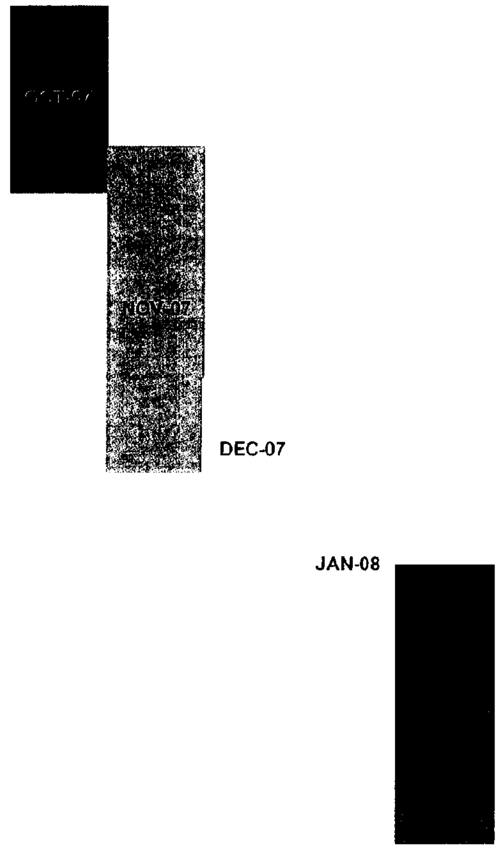
Figure 2-1
Summary of the Removal Design
Slip 4 Biological Assessment

Activity	Estimated Duration
Removal of Piling and Debris	5 days
Placement of Boundary Berm	2 days
Dredging	7 days
Bank Excavation	16 days
Bank Documentation Sampling	0 days
Acceptance survey	5 days
Bank Capping	12 days
Outfall Area Capping	9 days
Habitat Area Soil Cover / Large Woody Debris	5 days
Pier Demolition	15 days
Southern Armored Capping; Habitat mix under pier	8 days
Waterway Capping	19 days
Acceptance Survey	5 days
Cap Verification and Boundary Area Documentation	7 day
Prefinal Inspection	1 days
Corrective Measures (If needed)	4 days
Final Inspection	1 day
Demobilization and Cleanup	5 days

Timing



Note: If the proposed work does not occur in 2007/2008, it will occur when source control is determined to be complete.

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Figure 2-2
Summary of Preliminary Construction Schedule
Slip 4 Biological Assessment

TABLES

Table 4-1. Salmon Species in the Green/Duwamish River.

Species	Stock Origin	Production	Status	Spawning Period	ESA Status
Chinook—summer/fall					
Green/Duwamish	Mixed	Composite	Healthy	Sept–Oct	Threatened
Newaukum Creek	Mixed	Wild	Healthy	Sept–Oct	Threatened
Chum—fall					
Green/Duwamish	Mixed	Composite	Unknown	Late Nov–Dec	Not warranted
Crisp Creek	Hatchery	Cultured	Healthy	Late Nov–Dec	Not warranted
Coho					
Green/Soos Creek	Mixed	Composite	Healthy	Late Oct–mid-Dec	Species of Concern
Newaukum Creek	Mixed	Composite	Depressed	Late Oct–mid-Jan	Species of Concern
Pink—odd year					
Green/Duwamish	Mixed	Composite	Healthy	Fall	Not warranted
Steelhead—summer					
Green/Duwamish	Hatchery	Wild	Depressed	Probably Feb–April	Proposed Threatened
Steelhead—winter/early winter					
Green/Duwamish	Native	Wild	Depressed	Early March–mid-June	Proposed Threatened
Green/Duwamish	Hatchery	Cultured	Healthy	---	Proposed Threatened
Bull trout					
Green River	Native	Wild	Unknown	Unknown	Threatened
Coastal cutthroat trout					
Green River	Native	Wild	Unknown	Probably Feb–May	Not warranted

Sources: WDFW et al. (1993); WDFW (1998, 2000); King County (2000a); Cropp (2003, 2006, pers. comm.)
Notes: ESA = endangered species act

Table 4-2. Juvenile Salmonids in the Lower Duwamish River.

Species	Period of Greatest Abundance[a]	Habitat Type
Chinook salmon	Early May–June	Shallow and mid-channel
Coho salmon	Late April, late May–early June	Shallow nearshore and mid-channel
Chum salmon	Early April–early July	Shallow nearshore
Steelhead	Spring	Shallow nearshore and mid-channel

Sources: Matsuda et al. (1968); Meyer et al. (1981); USACE (1983)
Notes:
[a]Peak abundance is related to hatchery releases.

Table 4-3. Non-salmonid Fish Species in the Green/Duwamish River.

Species		Scientific Name	Abundance/Occurrence [a]
Pelagic			
	Surf smelt	*Hypomesus pretiosus*	Common/Estuary
	Longfin smelt	*Spirinchus thaleichthus*	Abundant/Estuary, Freshwater
	Pacific herring	*Clupea pallasi*	Common/Estuary
	River lamprey	*Lampetra ayresi*	Rare
	Three-spine stickleback[b]	*Gasterosteus aculeatus*	Common/Estuary, Freshwater
	Pacific sand lance	*Ammodytes hexapterus*	Common/Estuary
Demersal			
	Shiner surfperch	*Cymatogaster aggregata*	Abundant/Estuary, Freshwater
	Buffalo sculpin	*Enophrys bison*	Rare
	Starry flounder	*Platichthys stellatus*	Common/Estuary
	English sole	*Pleuronectes vetulus*	Abundant/Estuary
	Rock sole	*Lepidopsetta bilineata*	Common/Estuary
	Dover sole	*Microstomus pacificus*	Common/Estuary
	Butter sole	*Isopsetta isolepis*	Common/Estuary
	Hybrid sole	*Inopsetta ischyra*	Rare
	Sand sole	*Psettichthys melanostictus*	Common/Estuary
	Snake prickleback	*Lumpenus sagitta*	Abundant/Estuary
	Pacific tomcod	*Microgadus proximus*	Rare
	Pacific cod	*Gadus macrocephalus*	Rare
	Ratfish	*Hydrolagus colliei*	Rare
	Penpoint gunnel	*Apodichthys flavidus*	Rare
	Saddleback gunnel	*Pholis ornata*	Rare
	Crescent gunnel	*Pholis laeta*	Common/Estuary
	Bay goby	*Lepidogobius lepidus*	Rare
	Pile perch	*Rhacochilus vacca*	Rare
	Striped seaperch	*Embiotoca lateralis*	Rare
	Prickley sculpin	*Cottus asper*	Rare
	Pacific staghorn sculpin	*Leptocottus armatus*	Abundant/Estuary
	Padded sculpin	*Artedius fenestralis*	Common/Estuary
	Soft sculpin	*Gilbertidia sigalutes*	Rare
	Walleye pollock	*Theragra chalcogramma*	Rare
	Redsided shiner	*Richardsonius balteatus*	Common/Estuary
	Largescale sucker	*Catastomus macrocheilus*	Rare

Sources: Windward (2003b); USACE (1983)
Notes:
[a] Abundance and occurrence only provided for common and abundant species.
Abundance Citations: Weitkamp and Campbell (1980); Warner and Fritz (1995); West et al. (2001), as cited in Windward (2003b).
Occurrence Citations: Eschmeyer and Herald (1983); Battelle et al. (2001).
[b] The three-spine stickleback is also considered a demersal species.

Table 4-4. Bird Species Documented in the Lower Duwamish River.[a]

Common Name	Scientific Name
Canada Goose	*Branta canadensis*
Wood Duck	*Aix sponsa*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Mallard	*Anas platyhynchos*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Green-winged Teal	*Anas crecca*
Bufflehead	*Bucephala albeola*
Common Goldeneye	*Bucephala clangula*
Barrow's Goldeneye	*Bucephala islandica*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serator*
Common Loon	*Gavia immer*
Pied-billed Grebe	*Podilymbus podiceps*
Red-necked Grebe	*Podiceps grisegena*
Western Grebe	*Aechmophorus occidentalis*
Double-crested Cormorant	*Phalacrocoras auritus*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides virescens*
Turkey Vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
Bald Eagle[b]	*Haliaeetus leucocephalus*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperii*
Red-tailed Hawk	*Buteo jamaicensis*
Merlin	*Falco columbarius*
Peregrine Falcon[c]	*Falco peregrinus*
Killdeer	*Charadrius vociferus*
Greater Yellowlegs	*Tringa melanoleuca*
Spotted Sandpiper	*Actitis macularia*
Semipalmated Sandpiper	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
Dunlin	*Calidris alpina*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Bonaparte's Gull	*Larus philadelphia*
Mew Gull	*Larus canus*
California Gull	*Larus californicus*
Glaucous-winged Gull	*Larus glaucescens*
Caspian Tern	*Sterna caspia*
Pigeon Guillemot	*Cepphus columba*
Rock Pigeon	*Columba livia*

Table 4-4. (continued)

Common Name	Scientific Name
Vaux's Swift	*Chaetura vauxi*
Rufous Hummingbird	*Selasphorus rufus*
Belted Kingfisher	*Ceryle alcyon*
Downy Woodpecker	*Picoides pubescens*
Northern Flicker	*Colaptes auratus*
Western Kingbird	*Tyrannus verticalis*
Steller's Jay	*Cyanocitta stelleri*
American Crow	*Corvus brachyrhynchos*
Purple Martin[d]	*Progne subis*
Tree Swallow	*Tachycineta bicolor*
Violet-green Swallow	*Tachycineta thalassina*
Cliff Swallow	*Petrochelidon pyrrhonota*
Barn Swallow	*Hirundo rustica*
Black-capped Chickadee	*Poecile atricapillus*
Chestnut-backed Chickadee	*Poecile rufescens*
Bushtit	*Psaltriparus minimus*
Red-breasted Nuthatch	*Sitta canadensis*
Bewick's Wren	*Thryomanes bewickii*
Marsh Wren	*Cistothorus palustris*
Golden-crowned Kinglet	*Regulas satrapa*
Ruby-crowned Kinglet	*Regulas calendula*
Townsend's Solitaire	*Myadestes townsendi*
Hermit Thrush	*Catharus guttatus*
American Robin	*Turdus migratorius*
European Starling	*Sturnus vulgaris*
American Pipit	*Anthus rubescens*
Cedar Waxwing	*Bombycilla cedrorum*
Orange-crowned Warbler	*Vermivora celata*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*
Common Yellowthroat	*Geothlypis trichas*
Wilson's Warbler	*Wilsonia pusilla*
Spotted Towhee	*Pipilo maculatus*
Savannah Sparrow	*Passerculus sandwichensis*
Song Sparrow	*Melospiza melodia*
White-crowned Sparrow	*Zonotrichia leucophrys*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Dark-eyed Junco	*Junco hyemalis*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Red-winged Blackbird	*Agelaius phoeniceus*
Brown-headed Cowbird	*Molothrus ater*
House Finch	*Carpodacus mexicanus.*
American Goldfinch	*Carduelis tristis*
House Sparrow	*Passer domesticus*

Notes:

[a] Species observed from 2003 to 2006 (Desilvis 2006, pers. comm.)

[b] State and federal threatened species.

[c] Federal species of concern.

[d] Washington state candidate species.

Table 6-1. Habitat Acres by Elevation Range.

Habitat Elevation Range (ft MLLW)	Existing Conditions (acres)	Post Construction (acres)	Net Change (acres)
Upland (+12 to Top of Bank)			
Riparian (+12 to top of bank)	0.12	0.39	+0.28[a]
Aquatic (Below +12)			
Upper intertidal (+12 to +4)	0.31	0.80	+0.49
Lower intertidal (+4 to –4)	1.54	1.55	+0.01
Shallow subtidal (-4 to –10)	0.80	1.08	+0.29
Sublittoral (deeper than –10)	0.71	0.00	-0.71
Total aquatic	**3.36**	**3.44**	**+0.08**
Project Total			
Total acreage	3.48	3.83	+0.36

Notes: MLLW = mean lower low water

[a] Includes 0.15 acres riparian habitat enhancement.

Table 7-1. Potential Effects of the Proposed Action on Threatened Species within the Slip 4 EAA.

Common (Scientific Name)	Endangered Species Act Listing	Effect on Listed Species	Effect on Designated Critical Habitat
Puget Sound Chinook Salmon (*Oncorhynchus tshawytscha*)	Federal threatened species; state candidate species	May affect, but not likely to adversely affect	May affect, but not likely to adversely affect designated critical habitat
Coastal/Puget Sound Bull Trout (*Salvelinus confluentus*)	Federal threatened species; state candidate species	May affect, but not likely to adversely affect	May affect, but not likely to adversely affect designated critical habitat
Puget Sound Steelhead (*Oncorhynchus mykis*)	Proposed for federal threatened listing	May affect, but not likely to adversely affect	No critical habitat designated
Bald Eagle (*Haliaeetus leucocephalus*)	Federal and state threatened species	Will not affect	No critical habitat designated

Notes: EAA = early action area